APPLIED HYDRAULICS

The Magazine of Fluid Power Transmission

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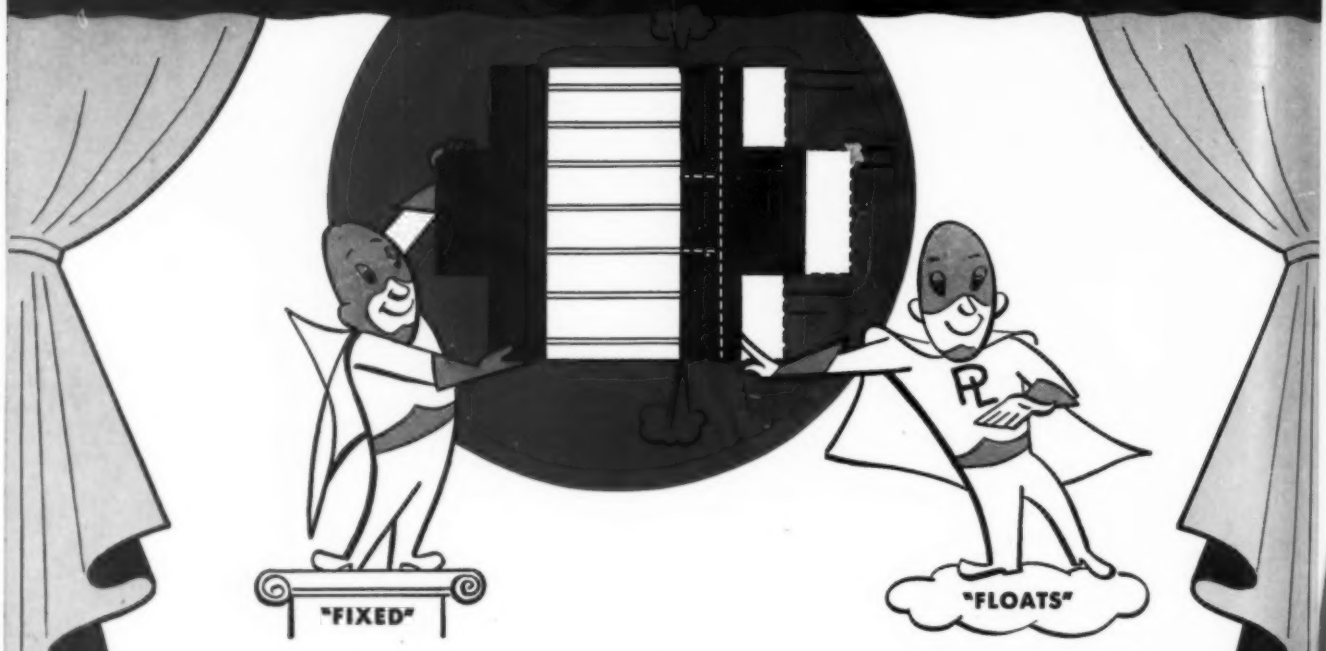

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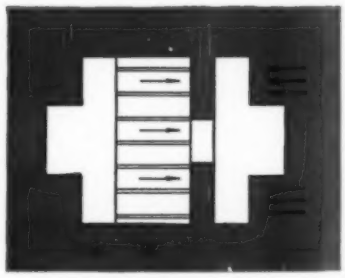

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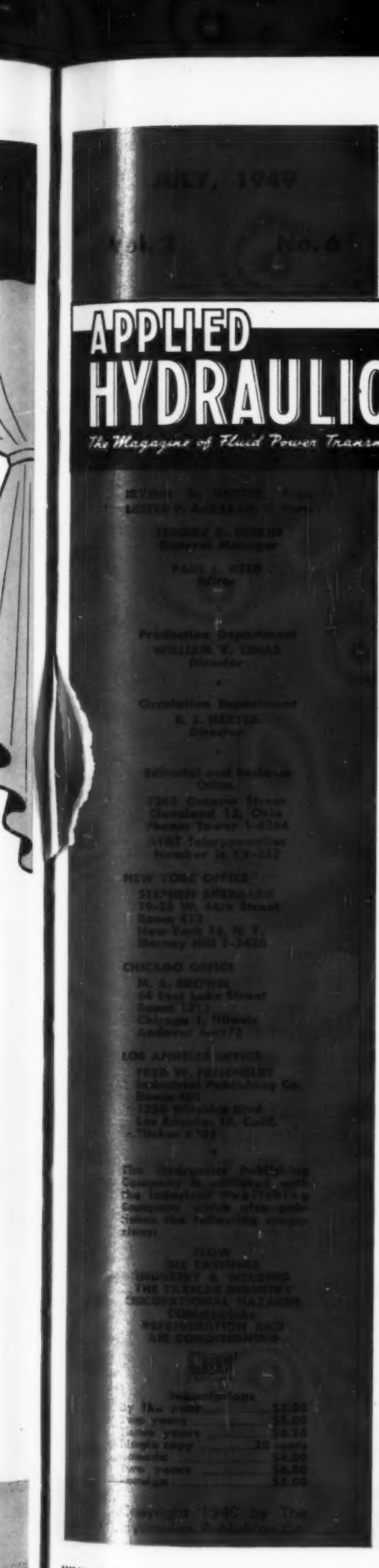

APPLIED HYDRAULICS

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FRONT COVER: A foot valve operated air cylinder lift in the Westinghouse Life-Line motor plant is used to raise wound stators to the correct height for hooking onto a Jarvis-Webb overhead chain conveyor. The conveyor takes stators from winding and connecting groups through a series of baking ovens and thermoset varnish dips for insulating the coils.

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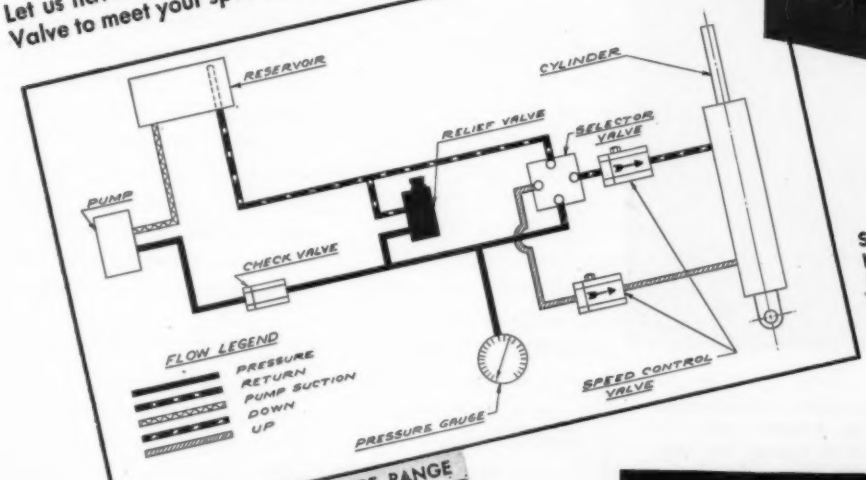

Schematic drawing, at left, shows typical installation of Electrol Relief Valve being used to by-pass excessive fluid pressure.

MODEL #			PRESSURE RANGE
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AIR-HYDRAULIC TEAMWORK IN BATCH RECLAIMING RUBBER

An arrangement for the automatic preparation and distribution of batches of reclaimed rubber and compounds to mixing mills in which a series of interrelated air and hydraulic circuits are used, is described. This system, whose creation was stimulated by a wartime emergency, has resulted in savings in excess of $100,000 to date.

By EARLAND E. HARVEY
Chief Engineer
U. S. Rubber Reclaiming Co., Inc.
Buffalo, New York

Fig. 1. The load selector slide assembly. A container is shown moving over a receiving hopper with the carriage slide assembly (top) about to engage the cam of the by-pass. The latch is on the rear side of the container and the unlatcher cylinder is shown under the container. The unlatcher valve has been put in its up position, ready to be contacted, by the extension of its cylinder (lower right). The pilot operated three-way valve is shown on the side of the hopper.

A FULLY AUTOMATIC SYSTEM FOR preparing and distributing batches of reclaimed rubber and compounds to mixing mills, which utilizes many ingenious applications of air and hydraulic circuits, has been in operation for several years at Plant One of the U. S. Rubber Reclaiming Co., Inc., at Buffalo, New York. Essentially a system of conveyors, weighing and loading operations, functioning of loading and unloading hoists, slide assemblies for various operations, emergency stops and interlocking controls, all are either actuated or controlled by air or hydraulic circuits.

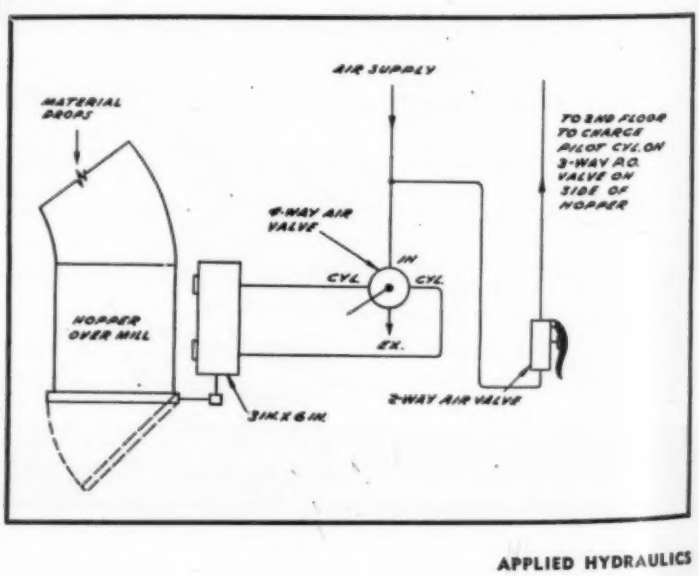


Fig. 2. The circuit for selection of loads. The mill operator presses the two-way valve, charging the pilot cylinder on three-way pilot operated valve on side of hopper. This, in turn, charges the slide assembly cylinder. When the cover closes this charge is released, the back slide assembly contacts an air valve momentarily to release air from the pilot cylinder.

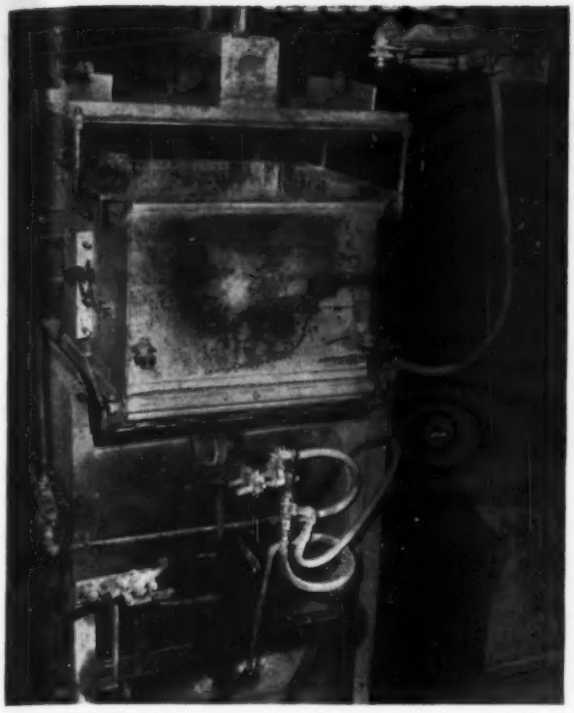
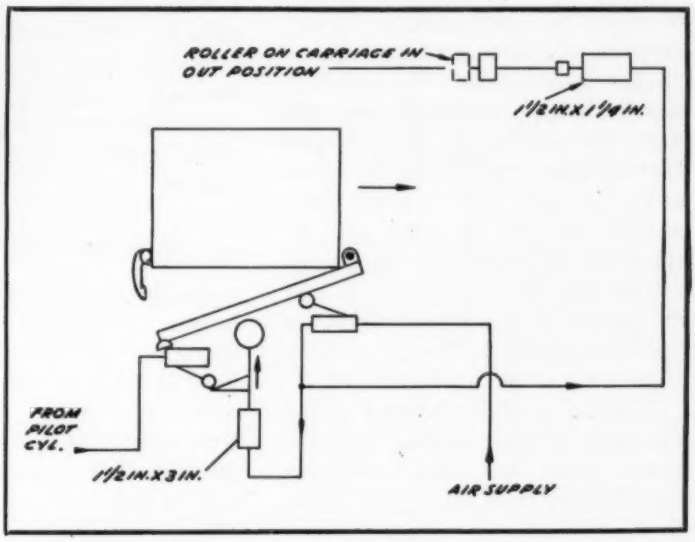


Fig. 3. The closing slide assembly. The view shows trip eyes, hooks, slide assembly in carriage and cylinder operated slide assembly. The container has just dumped and as it moves away from the hopper, the cover rolls up over the inner roller, then engages the roller on the lever of the air valve, actuating the slide assembly to finish closing the cover. The air valve used to release charge from cylinder of pilot operated three-way valve is at the left as is the square rod with hole positions for the unlatcher valve.

Fig. 4. The circuit of the back slide assembly for closing container covers after dumping. The operation may be checked against photograph, Figure 3. The inner (right) roller partially closes the cover by cam action, the action of the vertical lever of the air valve actuates the slide assembly to complete the cover closing.



The system described was developed to meet a critical wartime production requirement. Mills supplied by this system were originally hand fed by male help but, due to serious inroads on personnel by the armed services, women had to be substituted. It can now be said that our country's supply of rubber was almost entirely exhausted; reclaimed rubber became a critical item and top output was necessary. Mill batches were of such weights that two women were required to replace each man. An automatic means of supplying these mills became extremely important, in view of the doubled labor costs plus the scarcity of suitable female labor supply.

The original ideas for an automatic feeding system were developed in a home workshop through the use of wood models in which all operations were worked out mechanically using cams, levers, rods, clevises, etc. Because of the fear that subsequent wear would render the system inaccurate in its timing, the all-mechanical idea was finally abandoned. Air and hydraulic means were decided upon, although a half scale model of conveyor and loading station actually worked with production materials in a demonstration before company officials. In this model a string served the purpose of a motor, the writer's wife actually functioning as the motive power. In view of an estimated saving of $25,000 annually, approval was quickly obtained to go ahead. This decision has been since justified by savings of over $100,000 thus far.

The system was designed with provisions for handling four different combinations. This has been done experimentally, although it never has been called upon by production requirements. Three combinations will be demanded on rare occasions; two combinations are very frequent, but more often only one is demanded.

The top of each load container, of which there are 56 in the system, has ten uniformly positioned slots into which the station control eyes may be dropped. Four of these slots are for rubber, six for compounds. Three of these slots are for future stations not yet installed. The control eyes are of stainless steel strips rolled into an eye at one end with sufficient tail to equal the slot depth.

In starting the system for the first time, the control eyes may be positioned in the container slots or they may be placed in position after the system has been in operation and a schedule change is required. The eyes may be relocated while containers are in the overhead conveyor circuit as long as the change is coordinated with the readiness of the mixing mills. Since the position of the eyes concern only loading stations, nearly 20 minutes is available for their changeover. This is a distinct advantage when making ready for more than one combination because certain proportions must be observed, depending on the number of each combination and the number of mills in operation. The workability of the batches being mixed will influence the number of mills in production.

These operations, normally performed each two days before changes, plus the weighing of the rubber, are the only manual operations performed in operating the system. Cer-

tain rubbers cake during storage; no attempt has been made to weigh these automatically.

The operator's position on an elevated platform affords him a complete view of the entire system; through openings in his grating floor he can watch operations going on under him. Within easy reach of his position are a series of buttons through which he can control the starting and stopping of the system in case of misfunctioning of any part of it.

The mixing mills on the first floor are supplied with prepared batches of rubber and compounds which are dropped into load receiving hoppers on the second floor. The batch is spouted to hoppers directly over each mill. The mill hopper has a hinged bottom which latches at the operator's side and is air cylinder operated at the mill operator's will. As the batch in the mill becomes thoroughly mixed, he removes it and dumps his storage hopper; then by operating an air valve, he sets the stage for another load.

The load receiving hoppers on the second floor have extended sides between which the load containers travel. These sides have guide rollers to keep the containers in a definite path. This overcomes the wobble normally present in an overhead conveyor when wheels pass over dirt or other obstructions in the wheel path.

Each of these hoppers has attached to it three air operated slide assemblies. One slide assembly on the front or entering side, is capable of pushing an obstruction in the path of the container latch to unlatch containers.

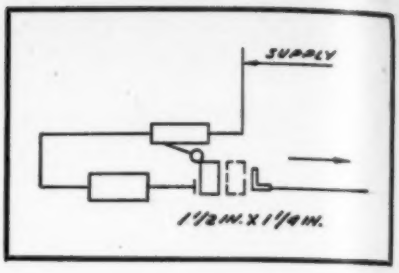


Fig. 5. The roller on the slide assembly on the upper bar of the carriage controls the operation of the hydraulic hoist valves and the by-pass arrangement. The roller in its unloaded, outer position, is returned to its inner, loaded position as the carriage passes under a valve which actuates a cylinder to return the roller.

Slide Assembly Control

On the side of the load receiving hopper is a slide assembly, Figure 1, by means of which the selection of loads is made. At the top of this assembly is a horizontally positioned three-way lever-operated air valve, attached to a square block which is free to slide on a square rod which has four holes for locking the block. As the block moves, the air valve moves with it. The lever of this valve projects into the path of the load container trip which will be described later. This valve actuates the unlatcher slide assembly on the front of the hopper.

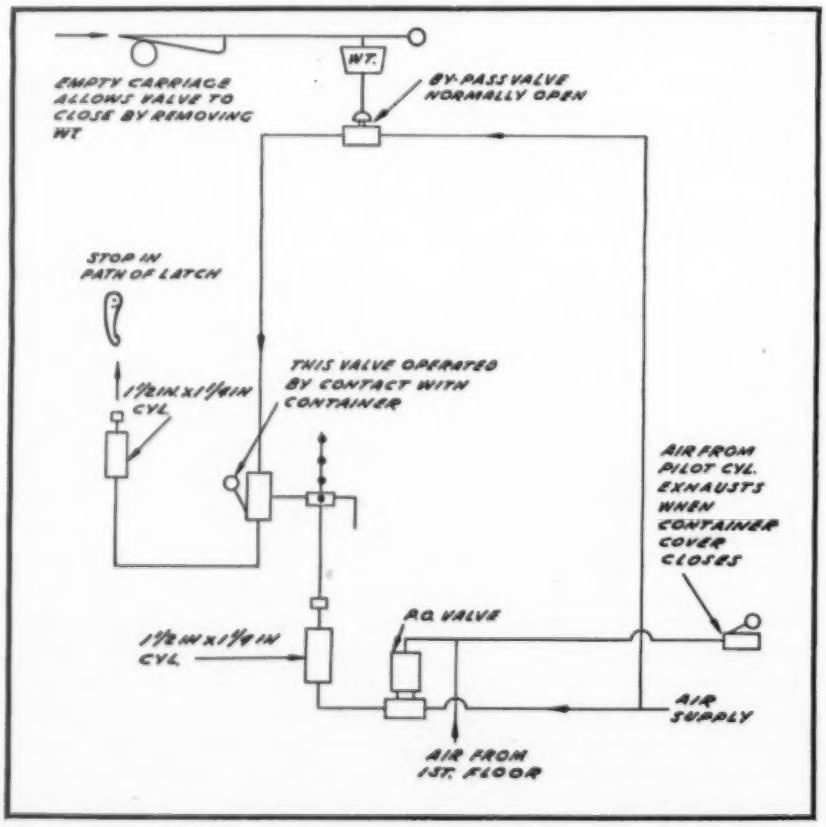
The air cylinder on this assembly is charged from the floor below by the mill operator. At his position is a two-way valve (Figure 2), which he presses to charge the pilot operated valve. This pilot operated valve charges the slide assembly cylinder. This charge is released when the cover closes; the back slide assembly contacts an air valve long enough to release the air from the pilot cylinder. When the mill operator desires a load he pushes his two-way valve. This puts the selector or unlatcher valve into the "up" position, into the path of the container trip projection. The unlatcher valve goes into action, the container dumps, the cover closes, the pilot charge is released and then valve drops into its "down" position.

On the back or leaving side of the hopper is a third slide assembly whose purpose is to close the container covers after dumping. This slide assembly, shown in photograph, Figure 3, and sketch, Figure 4, has a top mounted ball bearing roller which partially closes the container by cam action. A lever-operated air valve with its lever in a vertical position is adjacent to the roller. As the container cover passes over the roller it contacts the air valve lever, the movement of which actuates the slide assembly to complete the closing of the container cover.

The load container trip referred to is a weighted projection carried on any one of four pins attached to the side of a load container. This projection extends outward in a horizontal direction but is free to swing upward in case of misfunctioning. It has four

(Continued on page 14)

Fig. 6. A schematic diagram of the by-pass circuit.


WT.
EMPTY CARRIAGE ALLOWS VALVE TO CLOSE BY REMOVING WT
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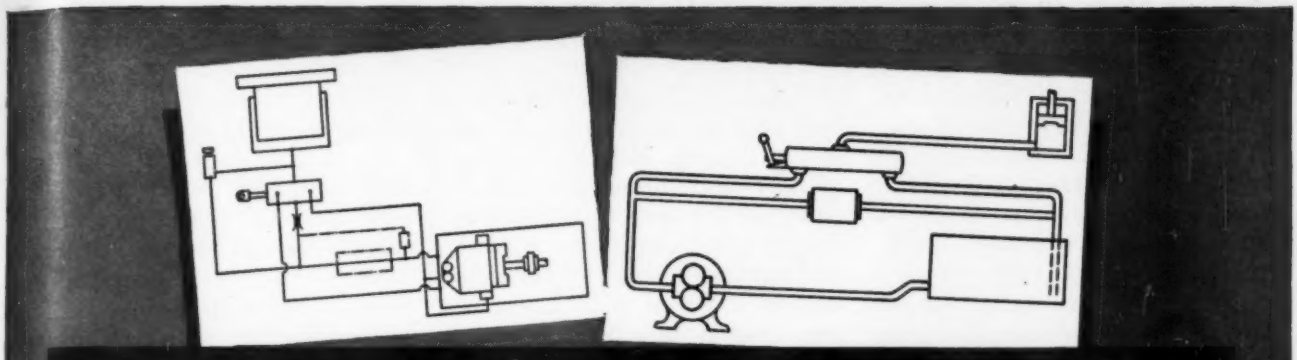
STOP IN PATH OF LATCH
1½ IN. X 1¼ IN CYL
THIS VALVE OPERATED BY CONTACT WITH CONTAINER
AIR FROM PILOT CYL. EXHAUSTS WHEN CONTAINER COVER CLOSES
1½ IN X 1¼ IN CYL
AIR SUPPLY
AIR FROM 1ST. FLOOR



A Beginner's Course in Basic Hydraulics

Chapter II

LIQUID FLOW
Continued

Kinetic energy, pressure and head relations in flowing liquids and the relation of static and dynamic factors are discussed.

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Kinetic energy. We have learned that a force must be applied to an object in order to impart velocity to it or to increase the velocity it already has. Necessarily, the force must act while the object is moving over some distance. Force acting over a distance is *work*. We have seen that work and all forms into which it can be changed are classified as energy. Energy, then, is required to give an object velocity. The greater the energy used, the greater the velocity will be.

In the same way, and disregarding friction, to bring an object to rest or to slow down its motion, a force opposed to its motion must be applied. This force also acts over some distance. In this way energy is given up by the object and delivered in some form to whatever opposes its continued motion. The moving object is a means of receiving energy at one point (where it is speeded up) and delivering it to another point (where it is stopped or retarded). While in motion the object is said to contain this energy as energy of motion or *kinetic energy*.

We have learned that energy can never be destroyed. Therefore, neglecting friction, the energy delivered to stop or retard an object will exactly equal the energy put in to speed it up. At all times the amount of kinetic energy possessed by an object depends upon its weight and the velocity at which it is moving.

To illustrate, force F in Figure 28 is applied to the body A, which is at rest. Disregarding friction, the body will possess kinetic energy equivalent to 1 after it has moved say one foot. During each succeeding foot of movement it will gain an equal in-

Fig. 28. A graphic representation of the force-movement relationship to accumulate energy to do useful work.

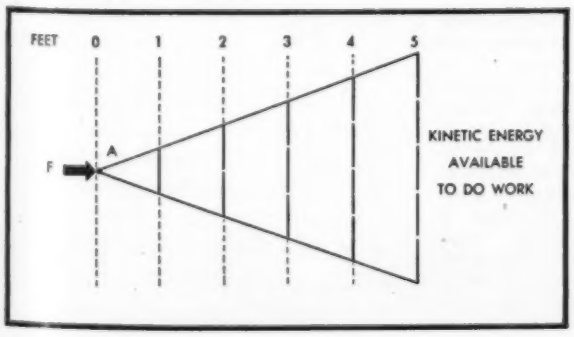
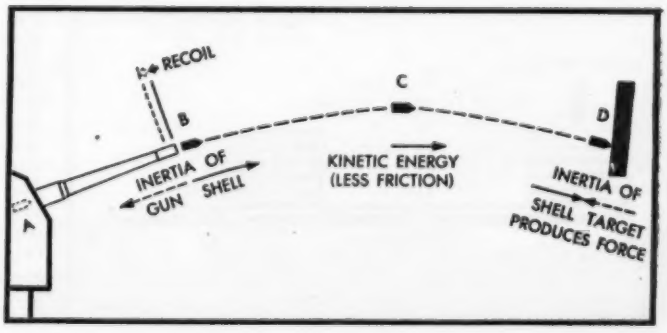


Fig. 29. The relationship of inertia, velocity and kinetic energy in terms of the firing of a projectile. Inertia of the shell resists movement initially and resists stopping terminally. Kinetic energy created by the work of firing is transferred by the shell to the target.



crement of kinetic energy, as long as the force is applied. If the body meets a resistance after moving five feet, a kinetic energy equivalent to 5 will be available to do work.

The mathematical relationship for kinetic energy is stated in the rule, "Kinetic energy in foot pounds is equal to the force in pounds which created it, multiplied by the distance through which it was applied; or to the weight of the moving object in pounds, multiplied by the square of its velocity in feet per second and divided by 64.3."

The relationship between inertia forces, velocity and kinetic energy can be understood by analyzing what happens when a gun fires a projectile against the armor of an enemy ship, Figure 29. The explosive force of the burning powder pushes the shell out of the muzzle, imparting a high velocity. Because of the inertia of the shell to taking this velocity so suddenly and the fact that the force acts equally on the breach of the gun, a reaction (kick or recoil) was set up which pushed the gun backward. Since the powder burns progressively, the force acts on the shell throughout its movement through the barrel (force acting through a distance producing work). This work appears as kinetic energy in the speeding shell.

The resistance of the air produces friction, using up some of the energy and slowing down the shell. Eventually, the shell hits its target and, because of its inertia, tries to keep on going. The target being relatively stationary, tends to stay that way because of its inertia. The result is that a tremendous force is set up which either leads to the penetration of the armor or the shattering of shell to bits. The shell is simply a means of transferring energy, in this instance for a destructive purpose, from the gun to its target. This energy is carried in the form of energy of motion or kinetic energy.

The situation described is shown in Figure 29. The shell is shown in four positions: at A, where it is at rest in the gun, just before firing; at B, a short distance beyond the muzzle of the gun, when its kinetic energy is at a maximum; at C, at mid-trajectory, where friction has used up a portion of its kinetic energy; and at D at the moment of impact, where its kinetic energy is suddenly transformed into work by its inertia and the opposed inertia offered by the target. Energy imparted to the shell at A has been transferred in the form of kinetic energy to do work at D.

In this diagram no effort was made to exhibit the magnitude of the force of gravity acting on the shell. It enters, of course, into the trajectory the shell takes. This situation differs from that shown in Figure 28 in that the propelling force in that Figure was continuously applied throughout the period covered by the diagram, while in Figure 29 the force was applied only while the shell was moving from A to B.

Relationship between force, pressure and head. In dealing with liquids, forces are practically always considered in relation to the areas over which they are applied. As we learned in Chapter 1, a force acting over a unit area is a pressure and pressures can either be stated in that form, i.e., as psi or in terms of *head*, which is the vertical height of the column of liquid whose weight would produce that pressure.

In most industrial applications of hydraulics, applied forces will be in a great majority and in most mechanisms the liquid is entirely confined. Under these circumstances it is customary to think of the forces involved in terms of pressure. Since the term *head* will be met frequently, it is necessary to understand what it means and how it is related to pressure and force.

Pressure and head relations in flowing liquids. All five of the factors (gravity, atmospheric pressure, specific applied forces, inertia and friction) which control the actions of liquids can be expressed either as forces or in terms of equivalent pressures or heads. However, in each situation the different factors are commonly referred to in the same terms, since on this common basis we can add and subtract them and otherwise study their relationship to each other.

Terms Defined

At this point we had better explain some terms in general use. Gravity head, when it is of sufficient importance to be considered at all, is often simply known as head. The effect of atmospheric pressure is frequently and improperly referred to as suction. Inertia effect, because it is always directly related to velocity, is usually called velocity head. Friction, because it represents a loss of pressure or head, is usually referred to as friction head.

Static and dynamic factors. The first three factors—gravity, atmospheric pressure and applied forces—apply equally to liquids at rest or in motion; the latter two—inertia and friction—apply only to liquids in motion. The first three are the static factors and the latter two are the dynamic factors. The arithmetic sum of the first three is the static pressure obtained at any point in a liquid at a given time. Static pressure exists in addition to any dynamic factors which may be present at the same point and time.

From Pascal's Law we learned that a pressure set up on a liquid acts equally in all directions and at right angles to containing surfaces. This is entirely true only for liquids at rest or practically at rest. It is true for the factors making up the static head. It was for that reason that we neglected friction in Chapter 1. Obviously, when velocity becomes a factor it must have a direction and, as explained, the force related to the velocity must also have a direction, so that Pascal's Law alone does not apply to the dynamic factors of liquid flow.

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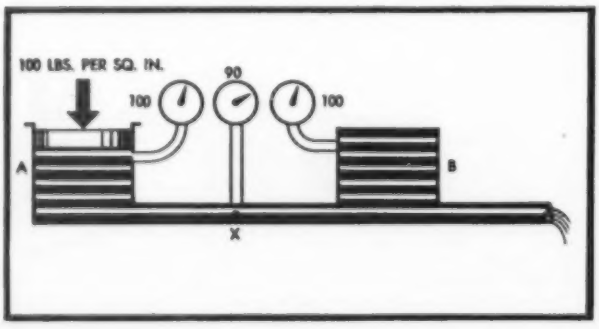

Fig. 30. The relation of static pressure and velocity pressure is shown on the gauges. Disregarding friction, the static pressure in chamber B would be equal to that in chamber A. Actually, pressure in chamber B would be less than that in chamber A by the amount of pressure used in overcoming friction.

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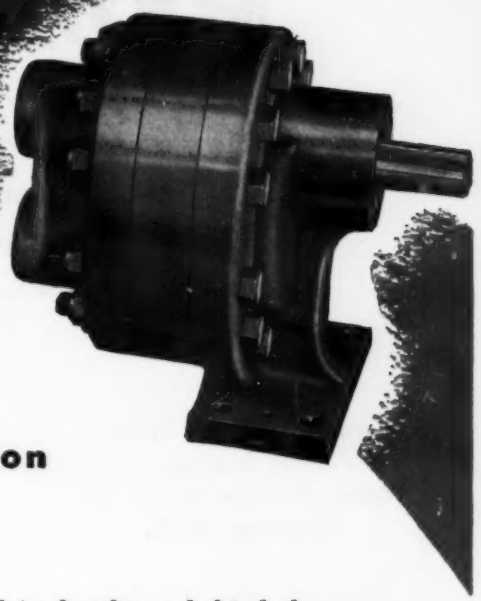

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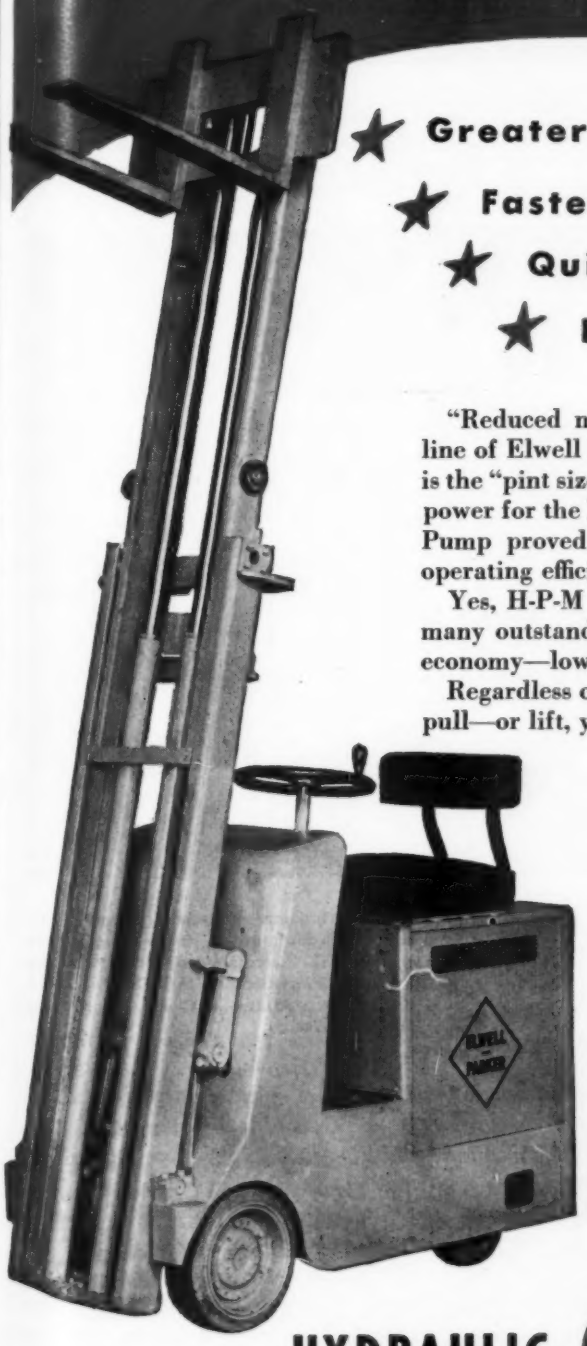

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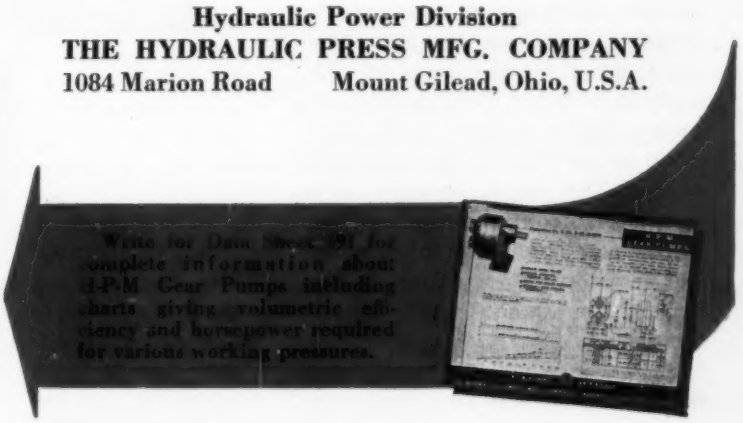

Write for Data Sheet 291 for complete information about H-P-M Gear Pumps including charts giving volumetric efficiency and horsepower required for various working pressures.

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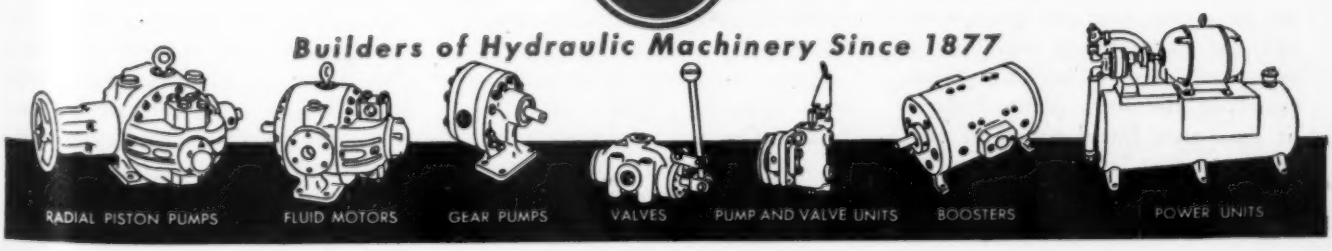

MADE TO ORDER POWER

How a molding company engineering and maintenance department revamped a high pressure hydraulic system without interrupting production—increased capacity and substantially lowered unit production costs.

By ARTHUR F. McCOY
Plant Engineer
Parker, Stearns & Co., Inc.
Brooklyn, N. Y.

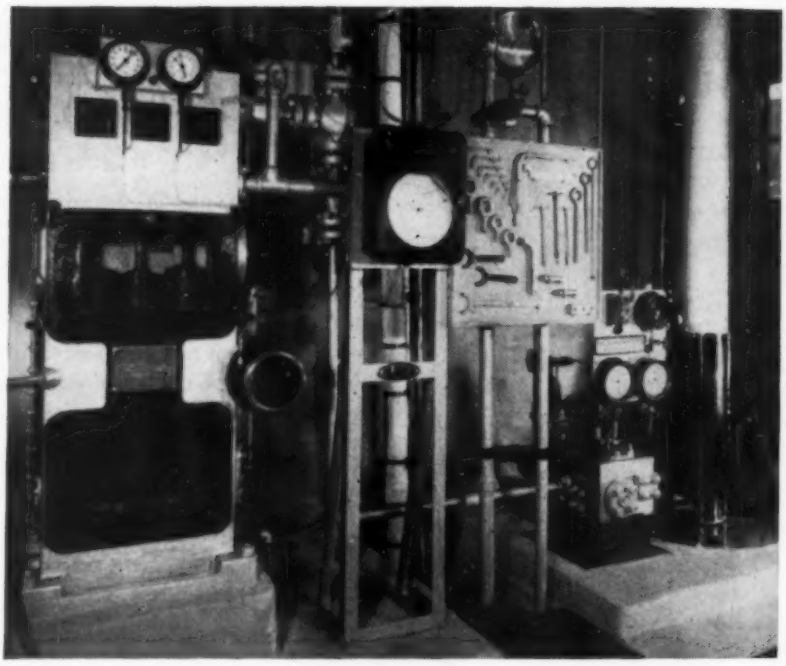

Fig. 1. The pump, pressure controller, safety shut-off valve and nitrogen bottles in the "accumulator room" at the Parker, Stearns & Company plant. All piping to presses runs in the grating covered trench.

THREE YEARS AGO THE CONDITION of our heavily loaded central station hydraulic pump system was such that our entire plant, in which we manufacture rubber and plastic products, was faced with a production shut down. It became necessary to replace a dead weight accumulator. Our analysis indicated that other changes would also be necessary or desirable. A decision was reached by management on the basis of this analysis to install a controllable capacity, high pressure hydraulic pump as the heart of the revamped system. The pump, installed at a cost no greater than a conventional replacement, provided an economy and flexibility of operation that has realized a substantial saving for the company.

The old accumulator would have required a complete rebuilding with an indefinite shut down of the plant. Because of its size, the accumulator had been placed in the mill room, where it occupied space that was needed for other purposes. It was too far away from the press room and the steam pump was too far away from the accumulator. When examined, the inside of the hydraulic lines were found rusted to such an extent that in some sections the open area was reduced to one quarter of the original inside diameter. Finally, all hydraulic, air and steam lines, shut off, regulators, downcomers, etc., were in overhead confusion and in poor condition.

Any one or two of these conditions would have been sufficient reasons for revamping the system.

The most important consideration in the changeover was the problem of plant down time. We were able to lay out, install and place the new system in operation without any interruption in production.

Space was found adjacent to the press room into which the equipment of the revamped system could be assembled. The new pumping plant, with a triplex, controllable capacity pump, nitrogen bottle accumulators, air operated, recording type pressure controller and automatic safety shut-off valve was installed in the new "accumulator room".

The controllable capacity pump is a high pressure, constant speed, variable delivery unit. In design this pump is a vertical triplex reciprocating plunger type, fitted with a simple automatic control for changing pump stroke. The pump is equipped to stop automatically should the oil pressure inside the pump fail at any time. In such a case, the automatic shut-off valve closes, sealing the liquid and gas in the accumulator cylinders at a predetermined pressure.

...FOR MOLDING

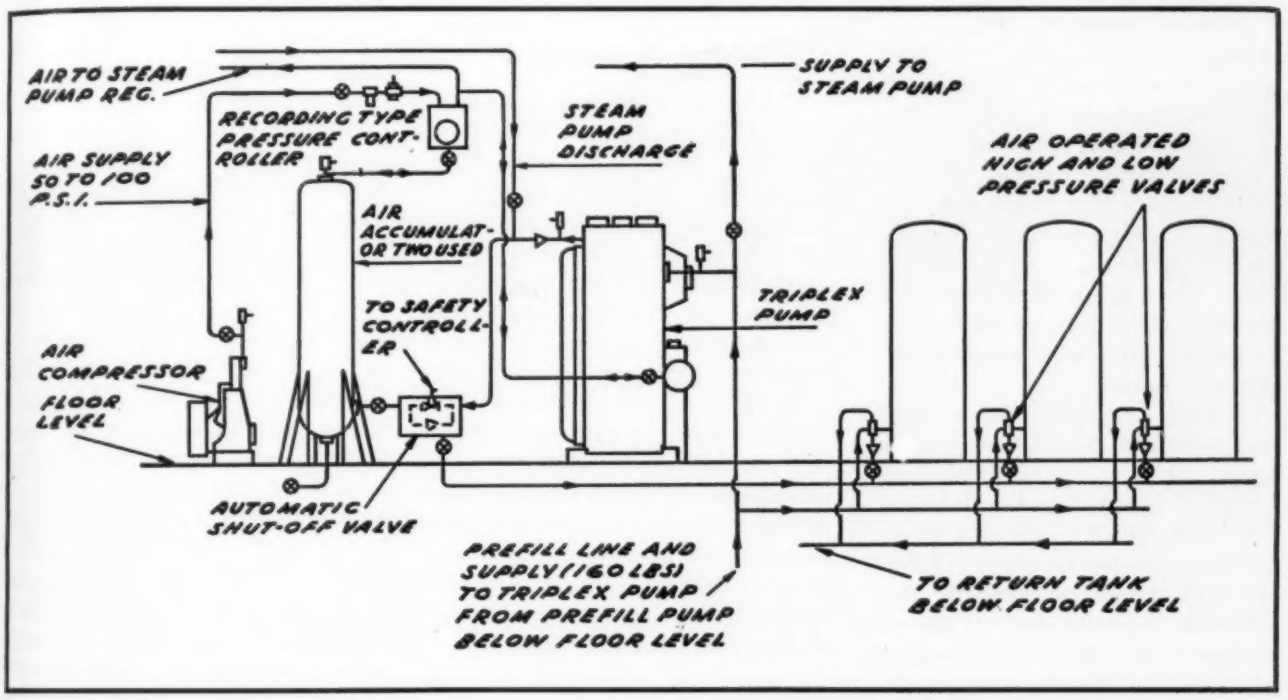
AIR TO STEAM PUMP REG.
RECORDING TYPE PRESSURE CONT-ROLLER
AIR SUPPLY 50 TO 100 P.S.I.
AIR ACCUMULAT-OR TWO USED
TO SAFETY CONTROLL-ER
AIR COMPRESSOR
FLOOR LEVEL
AUTOMATIC SHUT-OFF VALVE
STEAM PUMP DISCHARGE
SUPPLY TO STEAM PUMP
AIR OPERATED HIGH AND LOW PRESSURE VALVES
TRIPLEX PUMP
PREFILL LINE AND SUPPLY (160 LBS) TO TRIPLEX PUMP FROM PREFILL PUMP BELOW FLOOR LEVEL
TO RETURN TANK BELOW FLOOR LEVEL

Fig. 2. Schematic diagram of the revamped system.

The air operated pressure controller regulates the output of the pump. Set pressures are held steadily—almost impossible to do manually—while changes in pressure can be made almost instantly.

A two stage, double end centrifugal pump is used, both to prefill the hydraulic presses under low pressure and to supply the hydraulic pump with a suction pressure.

The original steam pump was completely overhauled and equipped with an air operated steam control valve. It is used as a standby unit. It can be operated simultaneously with the triplex pump if necessary. However, the steam pump does operate exceptionally well when the triplex pump is taken out of operation.

Two nitrogen bottle accumulators are used. These are much smaller than the dead weight accumulator previously used since their displacement merely compensates for the time lag of the pump, thus minimizing the pressure fluctuations in the system. Limit switches on the accumulator cylinders control delivery to and from the cylinders. Nitrogen is used for ballast.

An automatic safety shut-off valve was installed in the pressure supply-accumulator line. This valve closes automatically to prevent loss of nitrogen charge in the accumulator if, for any reason, there is a hydraulic failure of either the pump or the system.

The entire pumping plant is enclosed in a room which occupies less space than the original dead weight accumulator. All steam lines, hydraulic and air lines are located in a pipe trench. The grating shown in Figure 1 in the floor between the pumping unit and the shut-off valve gives ready access to all lines. The revamped system has been in operation for three years and has proven very satisfactory.

There are a total of thirty-three presses, ranging from one hundred to four hundred and fifty tons, now being served by the new system. Included is a battery of seven presses which were installed at the same time the hydraulic unit was installed.

Careful estimates indicate that the new hydraulic pumping system has made possible a saving of approximately 33 percent in production unit cost.

The new hydraulic pumping system has eliminated all the deficiencies and objections to the original system. It is compact, convenient, economical and efficient. It was laid out, installed and placed in operation without a single interruption in production. It has given increased capacity and flexibility for further expansion. Maintenance has been negligible and the company has been able to realize a substantial savings in unit production costs.

AIR-HYDRAULIC TEAMWORK IN BATCH RECLAIMING

(Continued from page 8)

positions to correspond to the four positions of the valve on the slide assembly at the side of the receiving hopper. The projection is set in position so that a load can be dumped only at hoppers which have a corresponding valve setting.

As noted previously, there are 56 containers in the system; 40 of these are in the overhead conveyor circuit and 16 are distributed along the floor conveyors. Each container on the overhead circuit is suspended from hooks on welded steel carriages which are suspended from two hanger bolts fastened to the conveyor chain. Holes in the carriages provide generous clearances for these bolts to permit carriages to negotiate the conveyor turns.

A slide assembly with a roller mounted on its end is situated on the upper bar of the carriage, centered between the two carriage hangers. The roller, which is held by a spring ball latch, has two positions. See Figure 5. In its outward position after emptying, the roller controls the operation of the hydraulic hoist valves and also the by-pass arrangement. The air cylinder on this slide assembly is operated by the same valve which controls the container cover closing mechanism.

The roller is returned to its inner or loaded position just ahead of the first station when the carriage passes under a valve which operates a cylinder to push the roller back.

By-Pass Arrangement

The by-pass arrangement consists of an air valve held in an open position by a spring actuated, cam shaped lever. Figure 6 is a schematic diagram of this circuit. Any load container on the overhead conveyor circuit which has already dumped will have its slide in the outward position. As such a container passes under the by-pass arrangement, the roller raises the cam, cutting off the air to the unlatcher valve on the hopper. For this reason, an empty container passing through a hopper calling for a load will not open. A container, once it has been dumped, will pass through the system without actuating any elements except the loading and unloading hoists.

Part II describing the loading and unloading hoists, the transfer section and the emergency stops will appear in the August issue.

BASIC HYDRAULICS

(Continued from page 10)

Relation of static and dynamic factors. The dynamic factors of inertia and friction are related to the static factors since velocity head and friction head are obtained at the expense of static head. However, at least a portion of velocity head can always be reconverted to static head. As we already know, force, which can be produced by pressure or head when we are dealing with liquids, is necessary to start a body moving if it is at rest, and is present in some form when the motion of the body is arrested. In other words, whenever a liquid is given a velocity, some part of its original static head is used to impart this velocity, which then exists as velocity head.

Examination of Figure 30 will make the relation of static and dynamic factors clear. We have a system consisting of a chamber A under pressure, connected by a tube to chamber B which is also under pressure. The pressure in chamber A will be wholly static pressure, say 100 psi. The pressure at some point X along the connecting tube will consist of a velocity pressure that we can conveniently say is 10 psi. This pressure will be exerted in a direction parallel to the line of flow. The 90 psi shown on the center gage represents the unused static pressure at point X. The static pressure still obeys Pascal's Law and operates equally in all directions. As the liquid enters chamber B it is slowed down, and in doing so its velocity head is changed back into pressure head. In other words, the force required to absorb its inertia equals the force required to get the liquid moving in the first place, so that the static pressure in chamber B will again be equal to that in chamber A, although it was lower at an intermediate point.

We have disregarded friction so that this situation would not be met in actual practice. Friction also requires force or head to overcome it, but, contrary to the inertia effect, this force cannot be recovered, although the energy represented still exists somewhere as heat. For this reason, in an actual system the pressure in chamber B would be less than that in chamber A by the amount of pressure used in overcoming friction along the way.

At all points in a system the static pressure will always be the original static pressure less any velocity head at a given point and less the friction head consumed in reaching that point. Since both velocity head and friction head represent energy which came from the original static head, and since energy cannot be destroyed, the sum of the static head, velocity head and friction head at any point in a system must add up to the original static head. Stated more simply, the total energy of fluid in steady motion remains constant. This general truth is known as Bernoulli's Theorem and is the second important basic law of hydraulics. It governs the relations of the static and dynamic factors; while Pascal's Law states the manner in which the static factors behave when taken by themselves. Figure 27 (June installment, page 17) illustrates this point.

Minimizing friction. Hydraulic equipment is designed to keep friction at the lowest possible level. Volume and velocity of flow are made the subject of careful study. The proper liquid for the system is chosen. Clean smooth pipe of the best dimensions for the particular conditions is used and is laid along as direct a route as possible. Sharp bends and sudden changes in section area are avoided. Valves, gages and other obstructions are designed so as to interrupt the flow as little as possible. Careful thought is given to the size and shape of openings. The system is designed so that it can be kept clean inside and so that variations from normal operation can be easily detached and remedied.

In August Chapter II is concluded with a discussion of measurement of flow factors, water hammer and a check list of elements of working hydraulic systems. Review questions and answers will be published. Be sure to save each installment.

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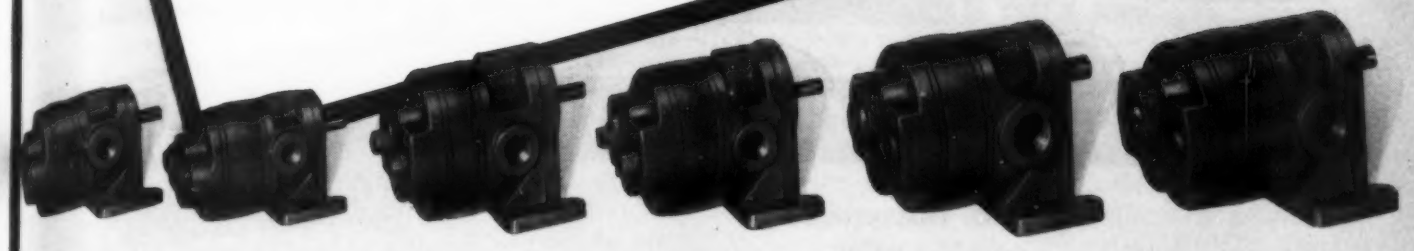

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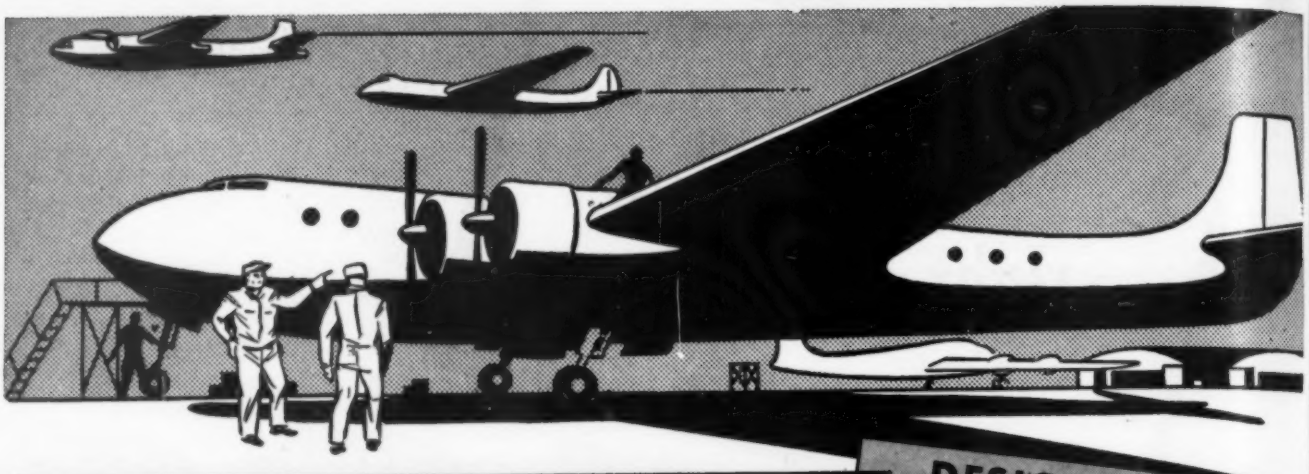


AVIATION HYDRAULICS

DESIGN
OPERATION
MAINTENANCE

FRED O. HOSTERMAN
Advisory Editor

The Problems of Hydraulic Systems in Large Airplanes

By DAVID GRANT

THE CONTINUOUS TENDENCY OF airplanes toward larger and even large sizes has increased both the functions and the performance requirements for hydraulic systems; hitherto unimportant problems have, in some cases, have become problems of major significance. With such designs, the necessity for the use of hydraulically powered primary flight controls has increased accordingly. The extremely exacting performance requirements have created a major change in the concept of hydraulic system design and changed the basic requirements of the aircraft hydraulic system from intermittent duty functions to continuous duty functions. The problems experienced in the past with development of hydraulic systems for operation of such services as landing gear retracting mechanisms, wheel brakes and wing flaps have become simple by comparison.

The nature of hydraulically powered primary flight control systems is undergoing basic changes as airplane size increases. Until recently, almost all designs making use of such flight controls used the power system as a "boost" for the pilot's effort and provided manual control with increased pilot effort in event of power failure. Manual control is no longer feasible in some of the present large airplanes because of the tremendous increase in flight control operating forces. As airplane size and performance is increased, it is apparent that new standards of reliability are required and that standby systems for emergency operation must become much more elaborate.

Some of the basic hydraulics problems will be presented; no particular attempt will be made to present solutions, which can be many and varied among different airplane designs, depending upon the design and performance characteristics.

One of the basic problems in the design of any hydraulic system is the selection of the system operating pressure. As airplane size increases it can be expected that hydraulic power requirements will also rise at least in proportion to the size. For this reason, present concepts of the optimum working pressure become obsolete, since as the loads increase, pressures can be raised to advantage in the interest of saving weight and increasing operating efficiencies. This is particularly true where it is necessary to transmit power over relatively long distances.

Figure 2 shows the results of a preliminary study made to determine the effects of operating pressure on the design of a hydraulic system in which the pumps deliver 50 horsepower and the transmission length is 300 feet. This data was based on the use of the lightest available tubing with a burst strength of

four times the working pressure. The fluid velocity was limited to 15 feet per second. The curves indicate that the transmission weight advantage ceases at pressures above 3000 psi; that the fluid weight decreases and transmission efficiency increases as pressure is raised somewhat beyond 6000 psi. If system efficiency is not critical, a further decrease in weight could be effected at the higher pressures by using smaller tubing and still equal the efficiencies at lower pressures. If extreme low temperature operation is required, the higher pressure systems would have a marked advantage due to the improved efficiencies. In addition, the lower mass of liquid in the higher pressure systems would reduce the surge control and time lag problems, which are important if flight control operation is involved. Cylinders, pumps and valves would be smaller and probably lighter in the higher pressure systems.

It would appear that the obvious solution is to determine the optimum working pressure for the airplane concerned and design for this pressure. However, there are practical considerations that prevent this. The primary consideration is that the development of high pressure hydraulic equipment has lagged behind the increases in the size of airplanes. Such basic components as pumps, fittings and seals are not sufficiently developed to enable use beyond the present Air Force-Navy specification limit of 3000 psi. The optimum efficiencies in the design of hydraulic systems for large aircraft will not be possible until the development of higher pressure equipment is accelerated.

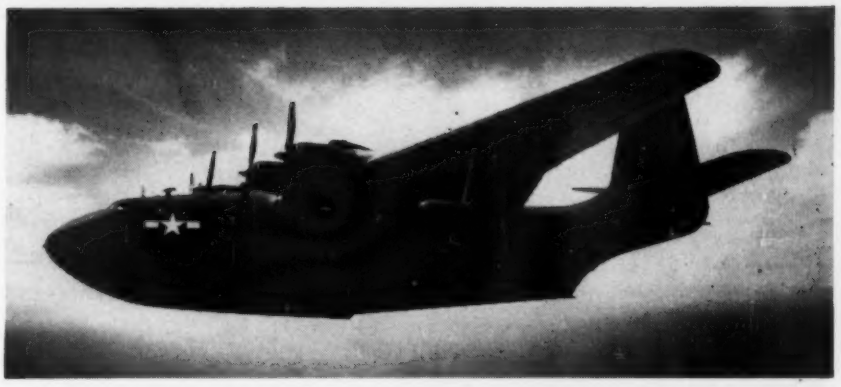


Fig. 1. The world's largest flying boat in active service, the Martin JRM-2, Mars, is shown in full flight. Named the Caroline Mars by the Navy, the plane is equipped with four Pratt & Whitney R-4360 engines, the world's most powerful aircraft engines.

Power Transmission System

The next problem is that of the power transmission itself. Faced with the limitations on working pressures, it would appear that the use of "packaged" hydraulic systems with electric motor driven hydraulic pumps, would be a desirable solution. Such systems would eliminate the long hydraulic transmission lines by the substitution of wiring. There has been a growing trend in this direction and the use of electric motor driven pumps and electrically controlled valves is steadily increasing. This approach is not without its problems and very careful consideration is necessary before a decision is made for this type of system. In the case of a very large airplane with hydraulically powered flight controls and no other means of control, this is an extremely difficult decision to make.

The electrical system itself must be considered. These systems are normally designed for relatively low continuous loads with highly intermittent peak loads, such as power for engine starters and propeller feathering systems. The peak loads never occur simultaneously and, in any case, are not comparable with the flight control peak loads. Therefore, it is necessary to add considerably to the electric power supply system to adequately power flight controls, which means additional weight.

In addition, the power requirements for aircraft electric motors have until recently been relatively low, with peak loads of a highly intermittent nature, so that high powered electric motors are not yet developed for aircraft; such motors would also involve a weight penalty. If any attempt is to be made to provide efficiently designed electric motors, the duty cycle must be established. This is difficult to accomplish for flight controls because of variations in pilot techniques as well as

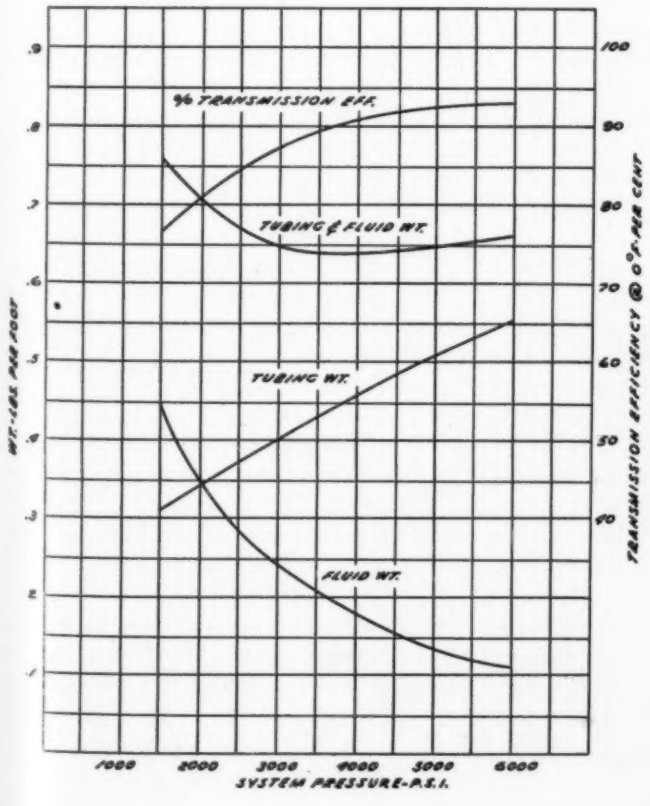


Fig. 2. The effect of operating pressure on the design of a hydraulic system in which the pumps deliver 50 hp and the length of transmission lines is 300 feet.

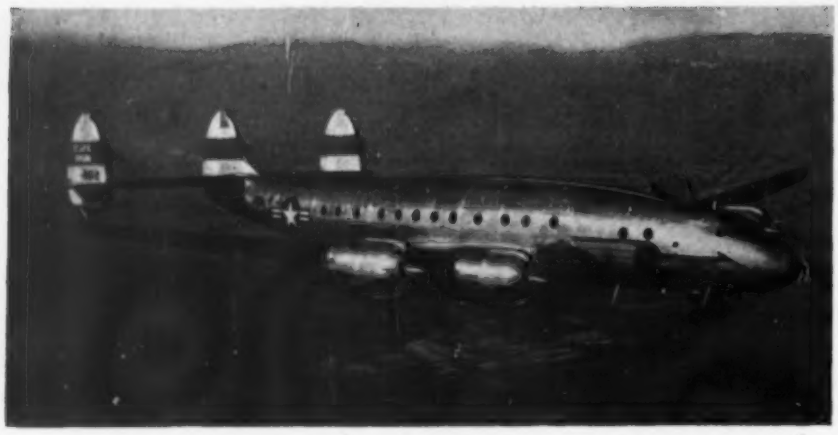


Fig. 3. The military model C-121A Constellation has been in service transporting airlift replacement crewmen for "Operation Vittles".

the difficulty in controlling the actions of service personnel in checking controls on the ground. There have been cases where electric motors were entirely adequate for the duty cycle in flight, but were burned out during ground test operations.

The disadvantage of relying on both the hydraulic and electric systems for operation of the controls must be recognized. Where the entire reliance for operation of the flight controls is on the hydraulic system, at least two separate and independent systems must be provided, either of which is sufficient for control operation. Simply providing separate electric motors and power systems for each of the two hydraulic systems is not considered sufficient for safety purposes, since it must be certain that a failure of one hydraulic system and the opposite electric system cannot incapacitate the airplane during flight. An additional complication is required, i.e., a relatively complex mechanical transmission enabling either electric motor to power either pump automatically. This again increases weight and cost and the reliability becomes more questionable.

The engine driven pump systems in large airplanes have their problems too. For example, there is the matter of fluid supply. It is usually necessary and desirable to have more than one pump in the system. These should be driven by separate engines to insure against hydraulic power failure due to engine failure. The distance between engines on large airplanes makes the reservoir location a problem. If only one reservoir is used to supply the pumps there will be at least one long suction line. This line will have to be large to hold pressure drop to a minimum. If the airplane must be designed to operate at low temperatures and high altitudes, the supercharge problem becomes magnified considerably. With long suction lines, relatively complex valves and other devices are necessary to insure adequate fluid supply to the pumps and avoid excessive pressure in the pump case for all operating conditions. These problems can be reduced considerably by providing separate reservoirs for each pump. However, multi-reservoir systems require the development of special devices in the return system to insure that some reservoirs are not over-supplied with return fluid while others are drained.

We can pass on to the pressure and return system. The high pressure line sizes will be limited due to the problem of obtaining satisfactory tubing and fittings. This limitation will determine the pressure drop in the system. The pressure drop can be expected to be appreciable for systems with high power requirements.

Initially, the heat dissipation from the long lines would appear to be an advantage. Actually, however, the system might have to be heated for extreme low temperature operation to maintain a reasonably efficient system performance.

The rapid acceleration and deceleration of large masses of fluid to operate flight controls in large aircraft creates surge problems that are far more severe than those of the past. Because of control response requirements, only a limited amount of modulation and damping is permissible for the valves. If this is not sufficient to reduce the surge pressures to aceptable limits, other complications must be introduced in the system. The surges necessitate that tubing supports be designed very carefully and stressed, not just "put-in" as they have been in the past.

Expansion joints are required for long runs of tubing to prevent undue loads in the tubing due to deflections in the fuselage and wings. Since no satisfactory high pressure flexible hose has been developed for the large tube sizes (e.g. 1¼ in), "slip joints" must be used. If these are sealed with standard "O" rings, the friction is considerable at high pressure; this stress also must be provided for in the structural supports. Further, the entire tubing support system is complicated by the need for allowing movement with respect to the structure.

Other problems, simple in the past, have become critical simply because of the size of the very large aircraft. One of these problems is load regulation for flight controls. Airplanes using the "power-boost" type of flight control depended upon the reversibility of the control system and the "feel-back" to the pilot to prevent overloads, much in the same fashion as the manually controlled systems. The boost ratios required in very large airplanes become so high they, practically speaking, approach infinity. Even if proportional "feel" is provided, it cannot be depended upon to prevent overloads. Relief valves with return lines to the reservoirs would not serve the purpose adequately, particularly in engine driven pump systems where the return lines must be long. This problem must be given special consideration to insure positive and reliable overload protection without hampering control operation.

Acceleration of Control Surfaces

The problem of designing a stable but responsive control system becomes much more difficult with the increase in mass of the control surfaces as airplane size increases. One of the special problems thrown upon the hydraulic system is to positively control accelerations of the control surfaces within safe limits. In the smaller airplanes the structural acceleration limit of control surfaces is so far beyond the possible operational accelerations that no special

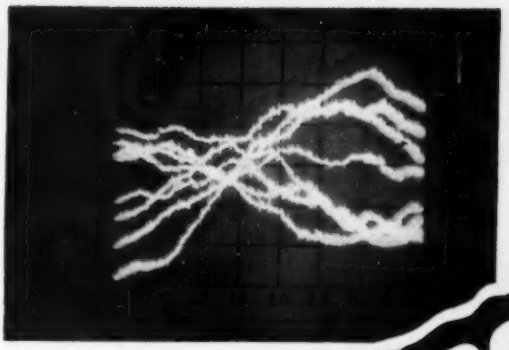
provisions are required. However, as airplane size increases, the control surface mass increases much more rapidly than the strength. The resulting narrow margin between the operational requirements and the safe limit of accelerations creates a major problem that requires careful analysis and extensive instrumentation and tests.

The necessity for elaborate standby systems was mentioned. In an airplane dependent entirely upon the hydraulic system for operation of the primary flight controls, it is considered a minimum requirement to provide at least two duplicate systems, either of which is capable of controlling the airplane independently of the other. This means duplicate pumps, valves, actuating cylinders, reservoirs and lines. Aside from the increase in weight, space, cost and installation problems, there are some really serious problems involved.

If the dual system arrangement is such that only one system is under power at one time, while the other is a standby and unloaded, the primary problem is in the transition period when switching from one to the other. In the event of failure of one system, it would be necessary for the other to provide power rapidly and automatically to hold the uncontrolled period to a minimum. In accomplishing this, it is necessary to provide sufficient damping to avoid violent and uncontrollable reactions to the control surfaces. This has been a troublesome problem in the past when power boost systems were turned on and off in flight. With this type of arrangement it is not possible to avoid some period during which the pilot has no control; the amount of damping required determines the minimum duration of this period. Unless the airplane is trimmed at all times during flight, this condition could be serious. Automatic trim tabs would, therefore, have to be considered in conjunction with this type of system.

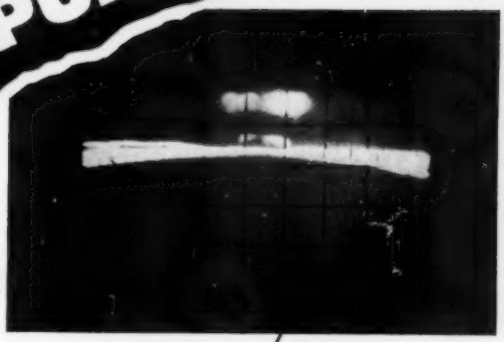
An alternate method of providing dual system operation is to have both system operating together normally so that, if one drops out, the other continues to operate, eliminating the transition period. In its simplest form each system would supply

(Continued on page 22)



BEFORE INSTALLATION OF ACCUMULATOR
Horizontal graduations equal 50 psi and full sweep equals 0.3 seconds. Without accumulator the maximum pressure swing of the surging fluid is 350 psi.

HOW TO IRON OUT PUMP PULSATIONS



AFTER INSTALLATION OF ACCUMULATION
Same installation with accumulator in system, the maximum pressure swing was reduced to 20 psi.

Pressure surges and pump pulsations are the two most common causes of pipe lines and hydraulic system failures. Surges and pulsations, however, can be greatly minimized or eliminated by installing a Greer Accumulator in the system. A simple "T" connection is all that is necessary to install it in any existing or newly designed circuit.

The "Before" and "After" photographs above give vivid proof of the effect of accumulators in hydraulic systems. A hydrauliscope and camera attachment were used to photograph the surges and pulsations of an actual pumping circuit. The "Before" picture shows the high degree of pulsations in the line not using an accumulator. The "After" picture shows how these surges and pulsations were effectively ironed out and virtually eliminated by the use of an accumulator.

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LEAKAGE CHARACTERISTICS Of Aircraft Hydraulic Units With Various Fluids

By FRANKLYN B. COLE, Jr.
Research Group Engineer
Lockheed Aircraft Corporation

THE PROCUREMENT OF HYDRAULIC equipment for production of aircraft is often a complex problem. One of the factors involved is that of supplying an assembly line with a continuous flow of valves and cylinders which meet satisfactorily the specifications of the aircraft manufacturer and the operator.

It is customary for the vendor of hydraulic equipment to satisfy himself that his product functions in accordance with pre-determined operational specifications before he delivers the unit to the user. The user, the airframe manufacturer, then processes the part through his own functional test laboratory before sending it to the assembly line stock room. One of the factors responsible for confusion and rejections is the difference in test methods and equipment employed by the vendor and by the user. In particular, the valve and cylinder leakage specifications are a continual bone of contention. It is our purpose to discuss the reasons for the trouble and to suggest ways in which correlation of test data may be improved.

The armed services require that all hydraulic units be flushed with rust inhibitor fluid AN-O-7 before storage. This leaves two courses open to the user testing group: (1) to conduct the test program with AN-O-366 fluid, followed by a flush with AN-O-7; or (2) to test directly with AN-O-7, eliminating the extra operation.

The question which frequently arises is: what difference in function is produced by the use of different fluids? The type of fluid, its condition, and the type of test equipment used by the vendor and the airframe manufacturer may produce widely varying results in leakage characteristics of some hydraulic units. The condition of the test fluid, types of test equipment and characteristics of aircraft valves are discussed in turn.

Condition of Test Fluid

Table 1 shows the results of analysis of the three types of test fluids now in use. Samples of new stock are compared with samples taken from production test benches. A study of this table reveals that the viscosity of the used fluids has been reduced by varying amounts, due possibly to the difference in age. It is worth noting that even the greatest decrease in viscosity could be compensated by a difference in fluid temperature of only 15 to 20 degrees F.

What is possibly a more significant variation has to do with filtration. It is a common occurrence to find a large lint content in new hydraulic fluid. This lint content is continually reduced as the fluid passes repeatedly through the filter. In general, it will be found that both the number and size of particles will be steadily reduced through continuous filtration until a minimum value has been reached. Satisfactory filtration is essential if the fluid is to remain in a condition of constant particle concentration after the initial lint removal. Contamination by careless handling of test equipment will frequently charge the test fluid with pieces of synthetic packing, wood, metal chips and other foreign particles which often cloud the issue when critical leakage tests are in process.

Another variable in fluid characteristics is lubricity. Tests were conducted in which the running friction of a dynamic "O" ring seal upon an anodized aluminum bore was determined for several fluids. These test results are shown in Table 2.

Table 1

FLUID CHARACTERISTICS

FLUID		Kinematic Viscosity at 100 F Centistokes	Particle Count x 10^5/cc	Size Range Microns	Surface Tension Dynes/cm
Specification	Condition				
AN-0-7	New	19.1	6.6	2 to 20	29.4
	Used	15.0	4.9	2 or less	29.0
AAF 3605	New	16.0	7.5	2 to 5	28.5
	Used	15.6	3.2	1 to 10	28.7
AN-VV-0-366b	New	15.0	6.4	1 to 10	28.6
	Used	13.8	2.7	2 to 20	28.4

Types of Test Equipment

A factor which is frequently underestimated is the effect of vibration and air entrainment on the leakage of hydraulic units. For ex-

Table II

RELATIVE LUBRICITY DATA

FLUID		Weight (grams) Required to Sustain Motion
Fluid	Condition	
AN-0-7	New	630
	Used	645
AAF 3605	New	555
	Used	610
AN-VV-0-366b	New	585
	Used	675

ample, if a certain valve is tested for leakage with a hand pump as the source of pressure and subsequently tested with power bench pressurization, it is very likely that substantially different leakage rates will be observed. The use of a hand pump sometimes results in inconsistent leakage data due to: (1) lack of vibration, which tends to seat spring-loaded valve poppet and slide valves; and (2) difficulty in bleeding a hydraulic unit completely when tested with the typical high pressure industrial hand pump. Table 3 indicates the inconsistencies encountered.

Conversely, the variation in vibration frequencies and amplitudes of various power test bench pumps and, even to a greater degree, the variation in fluid temperature produce a considerable spread in test data. Fluid temperatures should be held at 90 F plus or minus ten degrees.

Characteristics of Aircraft Valves

Most modern aircraft valves may be classified as either slide valves or poppet valves. Each of these main subdivisions has its special properties which are affected in different ways by the test fluids and equipment. Slide valves have higher leakage rates than do properly designed poppet valves. However, due to the abrupt action of poppet valves, many hydraulic applications require slide valves with their metering characteristics.

Numerous tests indicate that the leakage past slide valves is greatly influenced by the viscosity of the hydraulic fluid. Relatively small increases in fluid temperature result in higher leakage rates beyond the possible effects of thermal expansion of the metallic valve components.

Poppet valves containing dynamic "O" ring seals are often held off their seats by friction which is not overcome by the usual weak return springs. In this case, lubricity and packing swell enter into the picture.

The presence of solid contamination of any sort tends to increase the leakage of poppet valves; it may decrease the leakage of slide valves by tending to plug up the annular clearance between the sleeve and spool.

A general evaluation of test data covering many valve designs and fluid types indicates that a valve which has clear-cut leakage characteristics, either very high or very low, will maintain this pattern regardless of the hydraulic fluid used. The phrase "hydraulic fluid" employed refers to petroleum base oils in current use. However, in the case of valves in which leakage rates are marginal and which are considered critical for proper function in the aircraft system the effect of fluid properties is of definite importance. In cases of this type, the best approach is to make the basic functional test conditions conform closely to those which will be encountered by the valve in service. Expected temperature, vibration, type and condition of fluid and filtration efficiency should all be considered.

Possible Improvements

A study of the leakage problem inevitably results in ideas for improving the correlation of test data. In the case of valves which must seal tightly in order to be considered acceptable, it would be helpful if all testing facilities used the same basic parameters of measurement. These would include like batches of hydraulic fluid, equivalent filtration and cleanliness of equipment, reasonable fluid temperature control and similar vibration characteristics. These factors would eliminate numerous arguments and would make clear-cut any shortcomings of a particular unit.

The designer of aircraft hydraulic components could help the situation by recognizing and avoiding those particular design details or configurations which are susceptible to malfunction due to one or more of the factors discussed. The use of packings with friction which could affect seating of poppets and light, delicate springs should be avoided.

Summary

The conclusions which may be drawn from the foregoing discussion are:

(1) Valve and cylinders with very definite leakage characteristics are usually not affected as much by a difference in hydraulic fluid specification or condition as are units with marginal leakage properties. The latter type valves may produce inconsistent leakage data when tested under varying conditions of pressurization and fluid condition. It appears that greater variation in leakage may occur due to the condition of a hydraulic fluid than will result from a change from one specification fluid to another, e.g., a

Table III

VALVE LEAKAGE DATA, DROPS PER MINUTE

Notes: (1) Oil temperature: 70 to 80 F.
(2) Apparent inconsistencies in results may be attributed in part to entrained air and lack of vibration, since all tests were run with a high pressure hand pump.

FLUID		Brake Valve Slide		Steering Valve Slide	Shutoff Valve Poppet	Four-way Valve Poppet	
Specifications	Condition	No. 1	No. 2			No. 1	No. 2
AN-0-7	New	18	89	74	1	15	1
	Used	27	84	24	1	23	1
AAF 3605	New	30	101	110	1	24	1
	Used	25	35	58	1	3	1
AN-YY-0-366b	New	25	113	46	1	38	1
	Used	36	74	79	1	11	1

change from AN-O-306 to AN-O-7 fluid.

(2) The most practical approach to the processing of marginal equipment, assuming that the design cannot be improved in time for production deadlines, is to standardize on test methods, equipment and hydraulic fluid to be employed by all agencies testing the unit. Certain inconsistencies will always occur, since close control of test fluids between testing agencies is difficult to attain. Consequently, the functional test specifications should be set up with sufficient tolerances to provide for the inevitable difference in test results.

LARGE PLANE HYDRAULICS

(Continued from page 19)

half the power. Such a system would limit emergency flight operation since only half power would be available. It may, however, be desirable or necessary to have full power available at all times. Further complications are required to accomplish this without the possibility of overloading the controls in normal dual system operation. The dual system also introduces both mechanical and hydraulic synchronization problems that, in turn, require careful design and extensive tests.

It is desirable and should be possible to further extend the flexibility of the dual systems so that one of the systems operates some of the controls and the other system others in event of partial failures in each system. This is relatively simple to take care of if manual selection by the pilot is acceptable. However, automatic operation is required to obtain maximum benefits and to reduce the number of cockpit controls. This, in itself, is a problem with many pitfalls and loopholes, requiring major developments.

In a brief discussion it is difficult to single out problems created by the size of the airplane alone, since so many hydraulic problems are not directly related to size. We have only scratched the surface of the problems involved in designing hydraulic systems for the very large airplanes, both those being built and those that will be built in the future.

Quick Servicing OF ROPER ROTARY PUMPS MEANS SAVINGS FOR YOU!

One of the outstanding features of Roper design is easy accessibility to working parts. It is not necessary to disturb the pump mountings, motor mountings, or pipe connections to remove the pumping gears.

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The exploded view, at the left, shows the detail of disassembly of a Series F pump. Two cap screws, threaded in jack screw holes, pull the face plate . . . front flange bearings and gears slip out easily . . . case separates from back plate and back flange bearings are removed . . . back plate, pipe connections, pump and motor mountings remain intact. The stuffing box can be repacked quickly with split-type packing by removing two-piece gland. Quick servicing at lower cost!

Roper Series F pumps (illustrated) are for pressures up to 300 P.S.I. — built in 13 sizes up to 300 G.P.M.

EXPLODED VIEW OF MODEL "F" PUMP

Write for complete information

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ROPER Rotary Pumps

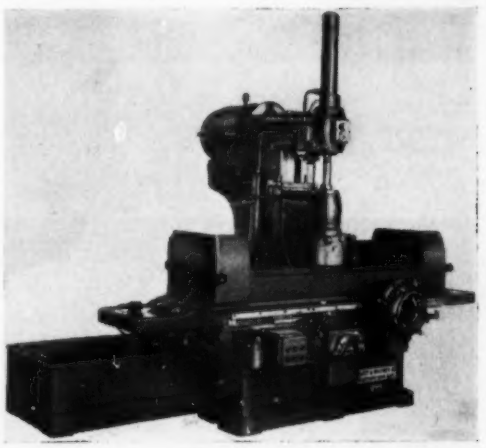
BUILDERS OF PUMPS FOR MANUFACTURING, MARINE, PETROLEUM, AND PROCESS INDUSTRIES

PRATT & WHITNEY

The Pratt & Whitney Division, Niles-Bement-Pond Company, leading manufacturers of a wide range of machine tools, special machines, gages, comparators, attachments and accessories, utilize hydraulic circuits in two lines of their widely used vertical surface grinders and gear grinders.

VERTICAL SURFACE GRINDERS

14 in Hydraulic Vertical Surface Grinders



General: A versatile grinder for rough or finishing work on small or medium size parts and for resurfacing dies. With table speeds from 3 to 100 fpm, practically every material than can be held in place, can be ground on the machine. The 12 in. x 36 in. standard table has a maximum travel of 47 in.; vertical feed, per revolution of handwheel, .080 in. (slow) or .240 in. (fast) with vertical power feed of .00025 in. to .005 in. per table stroke. This machine is also built with 60 in. table length.

Specifications: Circular No. 410-3.

Hydraulic Circuits: Table drive from a 5 hp motor and pump mounted at the rear of the bed. Two levers at the front of the machine control the drive, one reversing the table at the end of each stroke (hand or automatic dog operation), the other operating the valve which controls the infinitely variable speed. The automatic wheel downfeed is actuated by a hydraulic cylinder at each table reversal.

Attachments Available: Circular No. 410-3.

Operation, Service and Parts Manual: Submit serial number of machine.

Heavy Duty Hydraulic Vertical Surface Grinder

General: Available in both 26 in. and 30 in. segmental wheel models, these machines are amply powered (75 hp for the 26 in.; 100 hp for the 30 in.) for handling large work on the 18 x 88 in. tables to insure maximum removal of metal without any possibility of wheel hesitation. Vertical feeds, per revolution of handwheel .080 in. (slow) and .222 in. (fast). Vertical power feed .00025 in. to .005 in. per table stroke.

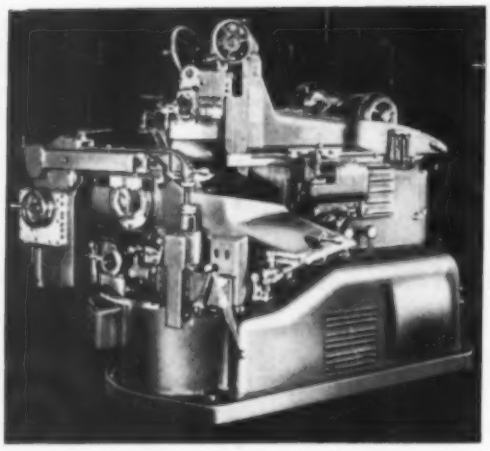
Specifications: Circular No. 494.

Hydraulic Circuits: A complete unit "power plant", consists of a direct-coupled 15 hp totally enclosed motor, variable delivery pump and integral tank isolated from the bed of the machine. Table reversal and vertical power downfeed are hydraulically actuated.

Attachments Available: Circular No. 494.

Operation, Service and Parts Manual: Submit serial number of machine.

GEAR GRINDERS



10 in Hydraulic Gear Grinder

General: Generating type for grinding both spur and helical gears, capable of production finishing of gears after hardening to .0002 in. Handles involute spurt or helical gears up to 10 11/16 in. OD maximum, 2 in. minimum root diameter, with regular master gear spindle; pressure angle 13 to 30 degrees inclusive, helix angle, either right or left hand, up to 45 degrees, inclusive. A two-wheel machine is also available.

Specifications: Circular No. 420-3.

Hydraulic Circuits: Ram operation by a 2¾ in. hydraulic cylinder; ram speed controlled by relief valve to produce speeds up to 50 fpm. Ram stroke adjustable for length and position by two dogs which operate reversing valve. The two speed table is driven by a 3 in. hydraulic piston and is reversed automatically. All indexing, reversing and speed controls are hydraulic and are interlocked when necessary.

Attachments: Circular No. 420-3.

Operation, Service and Parts Manual: Submit serial number of machine.

26 in Hydraulic Vertical Gear Grinder

General: A generating type of machine for accurate grinding of large spur and helical gears at very low cost. Handles involute spur or helical gears to 30 in. OD maximum. The wheel is passed vertically through each tooth space by the reciprocating hydraulic ram, grinding two adjacent teeth faces per cycle.

Specifications: Circular No. 496.

Hydraulic Circuits: All primary drives (except wheel drive) are hydraulically powered. Two multiple piston, variable displacement pumps, driven by a 7½ hp constant-speed motor, reciprocate the automatically reversing ram, operate the tooth generating drive and the column clamp. Adjustable dogs actuate solenoid switches to control limits of carriage travel, start and stop the index and the ram (wheel) reciprocation.

Attachments Available: Circular No. 496.

Operation, Service and Parts Manual: Submit serial number of machine.

General Information

Circulars listed are available on request from Pratt & Whitney, Division Niles-Bement-Pond Company, West Hartford 1, Conn. Requests for manuals or special bulletins will be honored when the serial number of a machine in operation is given and the request is made on a company letterhead.

All Pratt & Whitney machines, attachments and accessories are protected by issued and pending United States and foreign patents.

LETTERS to the Editor

Please advise me where I may secure the following information on air-water accumulators:

(1) What is the behavior of air and water in an accumulator at 6000 psi-10,000 psi?

(2) What is the depth of the layer of water saturated with air?

C.J.R.

A specialist in this field was consulted. In part he wrote to C.J.R.: The most generally used air bottle or bladder-type accumulator is designed for a maximum operating pressure of 3000 psi. With the pressures you require, the hydro-pneumatic type of accumulator should be considered. This type of unit, through the differential area between the hydraulic and the air side of the operating piston, allows the desired hydraulic pressure to be secured through the employment of a relatively low pressure air compressor. We do not know of any extended test data on a layer of water saturated with air as you describe. Such a layer has, as far as our experience is concerned, no practical value. Your saturation condition would change rapidly with: (1) the type of pumping equipment used; (2) the type of controls used; (3) changes in operating conditions; (4) ambient temperatures; (5) working volume of your accumulator; (6) the proportion of gas charge (normally two-thirds of the total volume of your accumulator); and (7) general maintenance factors which increase the accumulator demand in proportion to the maintenance of your valves, hydraulic mechanism, etc.

W.W.L.

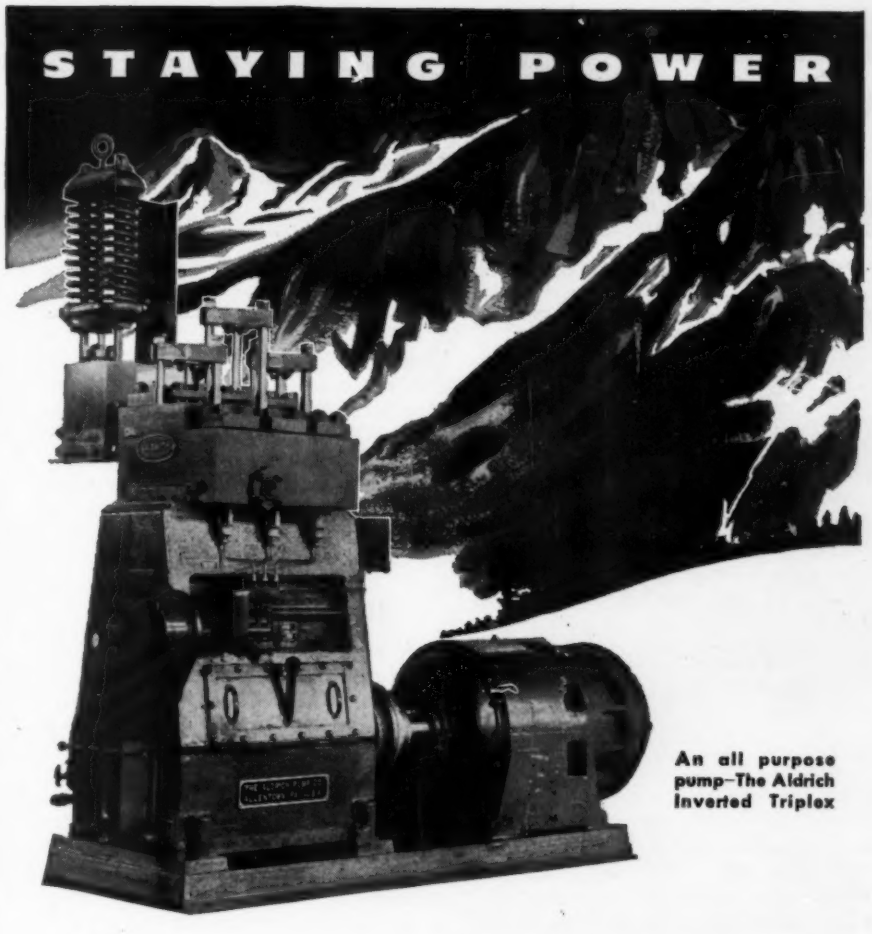
Can you give us the names of manufacturers of hydraulic duplicating attachments? Can these be adapted to any lathes or milling machines?

J.M.

Package type hydraulic duplicators, either standard or custom built, for application to practically any type of machine tool or to many special machines can be furnished by the Turchan Follower Machine Co., Detroit, or the Walker Hydraulic Duplicator Co., Standish, Mich. Several of the major machine tool manufacturers make hydraulic duplicating equipment for use with their own machines. Among these are: Cincinnati Milling Machine Co., Cincinnati, Ohio; the R. K. Le Blond Machine Tool Co., Cincinnati, Ohio; The Monarch Machine Tool Co., Sidney, Ohio; and the Lodge & Shipley Co., Cincinnati, Ohio.

We have your announcement regarding the Aviation Hydraulics Section you are starting with your June issue. We are glad to know that you will

(Continued on page 32)



An all purpose pump—The Aldrich Inverted Triplex

Mountains . . . there's rugged grandeur in a range of mountains—and staying power!

There's a similar power in the Aldrich range of high pressure pumps. Every industrial or engineering specialist knows that machinery must have *staying power*—the ability to maintain top performance and high efficiency over long periods of time. They know that interruptions are costly, while *staying power* pays. Aldrich Pumps have that *staying power!*

Take a look at the Aldrich design and construction that make rugged service easy. Note the plungers above the crankshaft, which provide for simplified drive—through speed-reducers or by direct coupling to a driver located on the floor. Expensive foundations are eliminated.

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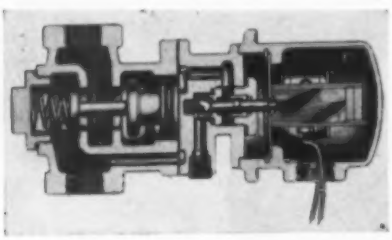
The **FIRST** *Name in Reciprocating Pumps*

New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

New In-Line Valves

Ross Operating Valve Co. offers a new split-second control of air power on machine tools and similar applications. The "Full-Flo" series of in-line valves provides a variety of sizes in



both three-way and straightway. The ¼-in sizes are pilot type, solenoid operated; models can be furnished with inlet ports either normally open or closed. An over-sized exhaust port makes the three-way models suited for fast reversal. Standard valves handle air, liquid or gas pressures to 125 psi. Special models can be supplied for use up to 450 psi. Interchangeable solenoid and pilot sections are used on all models simplifying service. Moving parts may be inspected without removing the valve from the line. One inch and 1¼ in models are available. *1.*

Hydraulic Boost Pump

A new Model C air operated, high-pressure hydraulic boost pump and companion Model C-R power unit are announced by Sprague Engineering & Sales. The pump, illustrated, was designed primarily for oil service; models are available with special bronze or stainless steel parts for water service or other corrosive fluids. The pump is capable of hydraulic pressure to 30,000 psi from available 100 psi plant air supply; it is

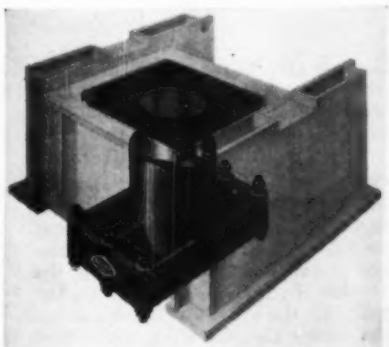
especially recommended where rapid ram travel is desired. The pump is available separately to replace hand operated types on most installations. The power unit, which includes the pump, is supplied complete, with reservoir, pressure gauge and control valves. *2.*

Diaphragm Pressure Switch

A new diaphragm pressure switch of unusual accuracy is announced by the Industrial Instrument and Gauge Division of The Electric Auto-Lite Company. The new switch can be made to make or break contact at an accuracy of plus or minus one-quarter pound. The model in production is designed to indicate pressures from 10 to 25 pounds but other switches to cover other ranges will be made available. *3.*

Die Cushions

Baker Brothers, Incorporated, has announced the addition of pneumatic and hydropneumatic die cushions for



all type power presses to the line of Baker machinery. The new pneumatic cushions are offered in standard sizes from 4 in through 28 in dia in the single piston type and from 10 in through 30 in dia in double piston type —the size and number of cushions in a given installation depending on the individual press bed construction and pressure requirements. Baker hydropneumatic cushions are always self-contained, and can be supplied to fit any press regardless of size or make. *4.*

Problem:
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Eastern GW Series ½ or 1 G.P.M. Pressures up to 200 P.S.I.

Built to stand the gaff of long, multiple-cycle non-lubricating liquid pumping, Eastern GW Series Pumps operate efficiently and economically. They're quiet, consume little power and deliver uniform performance day in and day out.

CHECK THESE FEATURES: Stainless steel drive gear; graphite carbon composition driven gear; no metal-to-metal contact; graphite impregnated bearing; hydraulically balanced:

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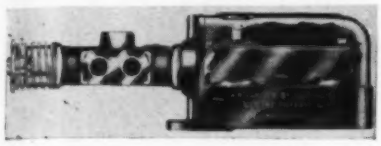
Pressure Leak Clamps

High pressure pipe leak clamps which withstand pressures of 1000 psi without leaking are offered by the Marman Products Co. Inc. As a permanent repair for high pressure pipes 2 in to 8 in, this clamp is unexcelled, according to the manufacturer. The Perbunan pad attached to the stainless steel band gives high strength and is corrosive resistant. There are no loose parts. The patch plate is movable allowing the take up bolt to be easily positioned. *5.*

Solenoid Air Valves

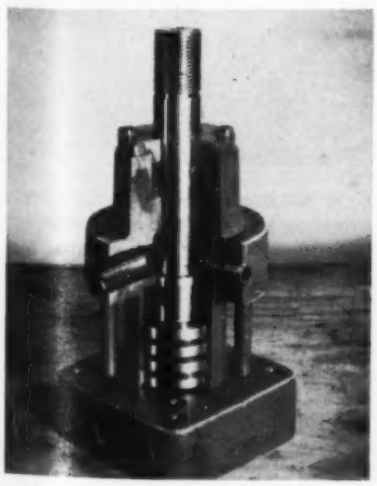
Valvair Corporation announces a new line of single solenoid valves for air pressures to 125 psi. The valve has a



one piece bronze base, heavy and powerful solenoid for positive seating and cool operation, heavy sheet metal cover, "OU" type packer and shock resistant clevis and clevis pin. Two-way, three-way open and exhaust (normally closed only), three-way piped exhaust and four-way piped exhaust models are available in ¼, ⅜ and ½ in sizes. *6.*

Hydraulic Cylinders

Pathon Manufacturing Co. is offering hydraulic cylinders in three pressure series: series EH (steel) cylinders for operation at 1500 psi, available in 12 bore diameters 1½ in to 9 in, in seven mounting styles; series CH (semi-steel) cylinders for operation to 1000 psi, available in the same bore diameters and mounting styles, and series MH (gray iron) cylinders for operation to 750 psi and available in six bore diameters from 4½ in to 9 in, and six mounting styles. Major features of construction include: honed



seamless steel tube cylinder barrels; mild steel or cast iron is used on the piston assembly which incorporates phosphate treated automotive type piston rings; and the use of a bronze bear-

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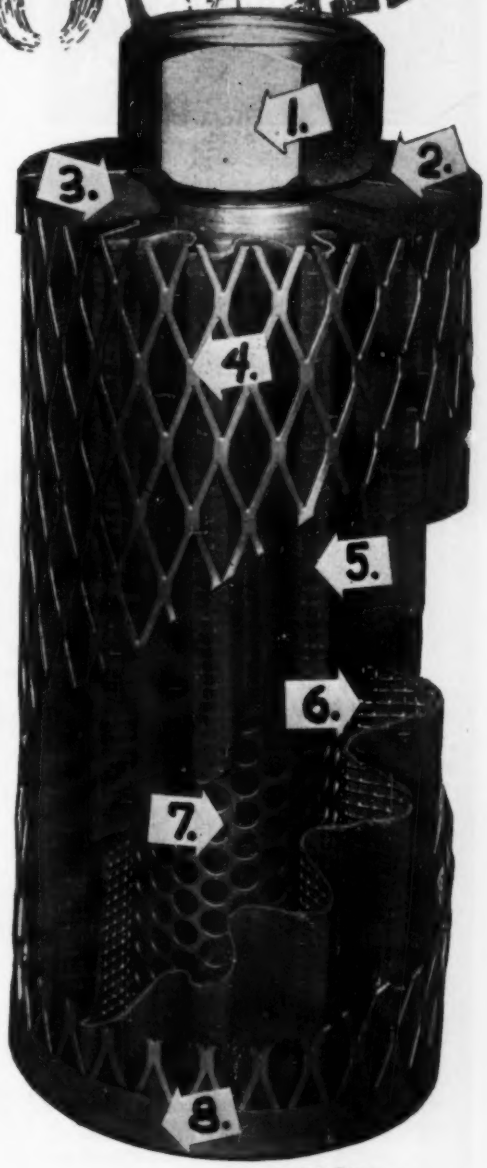

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2½ TIMES MORE FILTERING AREA
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COMPARE THESE FILTERING AREAS:

Model	Filtering Area Sq. In.	Capacity GPM
A-1½-50	340	50
A-1½-30	288	30
B-1¼-20	196	20
C-1- 10	108	10
D- ¾- 8	84	8
E- ¾- 5	56	5

COMPARE THE ADAPTABILITY:
Marvel Synclinal Filters have standard 100 mesh (.0050 openings) filtering elements—other elements range from 30 mesh (coarse) up to 200 mesh (fine). Adaptable to meet your filtering problem.

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An ever increasing number of **OEM** users are installing Marvel Synclinal Filters to protect and maintain continuous operation of the hydraulic equipment they manufacture. They know the harm that can be caused by dirty oil resulting from pipe scales, grit, other impurities, etc., which accumulates and clogs the small orifices in hydraulic systems. Let their experience be your guide to finer hydraulic operations.
Don't risk costly downtime when safeguarding costs so little. Keep hydraulic production lines moving with clean oil.

** Names on request.*

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REMOVING MOLD CORES FROM PIPE

APPLICATION—The use of Ledeen 3" diam. x 48" stroke cylinders has simplified the difficult removal of mold cores from concrete pipe. While removal of outer pipe forms is easy, the cores must be pulled vertically. They frequently stick, requiring tremendous pressure to start the motion.

OPERATION—Actuating cylinder is hydraulically operated at 1000 p.s.i. from a specially developed power unit. Mounted vertically directly over the pipe mold, the cylinder with its 48" stroke permits complete and quick removal of cores. Ample power makes the removal of every core as easy as turning a valve; spoilage is reduced and time is saved.

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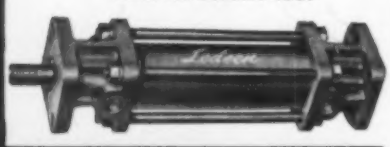
Ledeen heavy duty cylinders, operated by air, oil or water, will do it for you better and surer.

Standard Ledeen Cylinders with rod or head attachments are available from distributors' stock in major cities. Special cylinders on order.

Write for Bulletin 453.



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Ledeen Mfg. Co.

DIV OF ENGINEERING PRODUCTS CO

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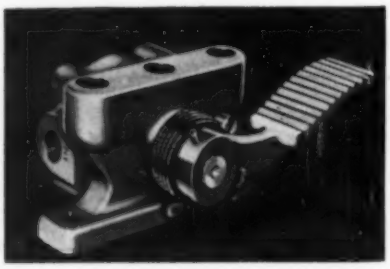
ing in the ram end cylinder head to take the side thrusts and gravity loads. In larger sizes the same supporting effect is obtained by boring and honing the casting to very close tolerances and approximately 8 micro-inch finish. *7.*

Redesigned Foot Valve

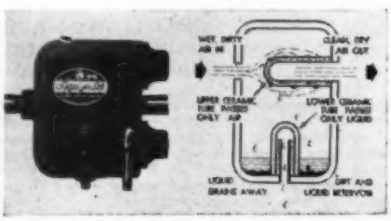
Redesigning of the Model "F" and Model "R" NOPAK Foot Valves by the Galland-Henning Mfg. Co. has resulted in installation and operating advantages. The principal change in the design of the valves is the elimination of the internal exhaust core in the valve disc. This change gives a larger, more effective exhaust area, greatly increasing valve capacity and reducing the possibility of plugged passages. Another feature is the location of the cylinder and exhaust ports which are now located on the flat, top surface: resulting in a more compact and streamlined appearance. Either valve



can be used as a two-way shut-off or as a three- or four-way operating valve. While primarily designed for air service, they may be adapted to oil or water hydraulic systems up to 100 psi. *8.*

Air Line Cleaner

A newly designed Liqui-jector, for removing water and water-oil emulsions automatically and continuously from compressed air and gas lines, is announced by Selas Corporation of America. The unit is utilized in precision pneumatic operations that require positive conditioning of air or gas. Phase separation and liquid ejection are accomplished by two ceramic tubes; one water-repellant; the other water-permeable but air-impervious.



Air passing through the top tube is stripped of its moisture and dirt. Moisture drains through the bottom tube without loss of air. The unit also acts as a filter, removing solid particles down to less than 100 microns. The housing is cast bronze and there are no moving parts, traps, cocks or shut-offs. The Liqui-Jector is available in three sizes to extract water at rates of 0.5 to 2.5 gallons per 24 hours. *9.*

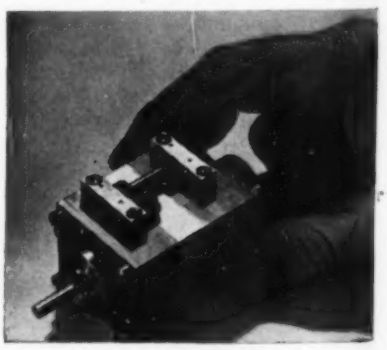
Portable Hydraulic Tester

A new portable hydraulic system tester for use with the smaller aircraft has been introduced by the Manufacturing Division, Pacific Airmotive Corporation. Two models are available—one provides one gpm at 1600 psi, the other 3 gpm at 1000 psi. The stands

are small, easily moved from job to job and feature quick disconnect couplings on all hose. Variable volume control is optional. The units operate on 110-220 v ac. *10.*

Clutch-Brake Servo

A small compact clutch-brake type servomechanism has been announced by Buehler and Company. Designed as a component for remote positioning, process control, computers and similar applications, the clutch-brake principle



offers unusually accurate servo performance with speed and torque outputs superior to other servos of comparable size and weight. Input is supplied to side gearing, allowing for convenient stacking of units from one input shaft; output is taken from the center shaft. The unit is available separately or furnished as a complete packaged servo with suitable amplifier for operation from power sources of various frequencies and voltages. *11.*

Motor Operated Shut-Off Valve

Saval, Inc., announces that unqualified yellow dot approval has been granted on its No. 6400 motor oper-

ated 1¼ in aircraft fuel shut-off valve. Designed for less than one second actuation, the valve features minimum weight and size, interchangeability and convenient installation. The same type valve is also available in a range of standard tube sizes for hydraulic oil, air and lubricating oil service at both normal and elevated temperatures to 500 F. *12.*

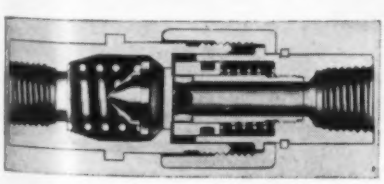
Explosion-Proof Switch

The Meletron Corporation has announced the addition of a new explosion-proof pressure actuated switch, model No. 320, to their line of pressure and vacuum actuated switches. The new model incorporates a Bourdon tube in a separate housing, stainless steel optional, which actuates an explosion-proof Micro Switch. The switch is approved by Underwriters for hazardous locations, Class 1, Groups C & D; Class 11, Group G.

The Model 320 is built to provide pressure control from 25 to 10,000 psi for a maximum system pressure to 12,000 psi. Adjustments in pressure settings are possible without disconnecting or exposing the electrical circuits. *13.*

Self-Sealing Couplings

Self-Sealing Couplings for lines carrying hydraulic fluids, air, water, fuel and other oils at temperatures from —40 to 250 F are offered by Aeroquip Corporation. They solve the problem of disconnecting fluid carrying lines without draining the system and re-priming.



With Aeroquip Self-Sealing couplings it is possible to separate and reconnect fluid-filled lines without the loss of fluid or the introduction of air into the systems. A considerable saving in time and expense is made for each separation of the line for servicing. An "O" ring packing in the larger sizes provides an additional seal which effectively prevents external leakage when the union nut is hand-tight. A poppet valve is held firmly against its seat by the force of a spring—the sealing arrangement is in direct proportion to the fluid pressure —higher pressures give better seals. *14.*

Center Hole Ram

The new Hydra-Pull ten ton ram with a center hole is now ready for national distribution according to the Sunset Hydraulic Co., manufacturer. The center hole runs through the full length of the ram, allowing the use of a drawbar, giving a direct pull of greater pressure than an ordinary ram. The ram is separated from pump by a quick coupling flexible hose, enabling it to operate in any position. Hydra-Pull is designed for pushing, pulling, bending, straightening and assembling. They are particularly useful in testing valves. Various attachments that thread on the ram and are interchangeable with the rams are available. *15.*

Cone Check Valves

Cone check valves of The Parker Appliance Co. which meet AN aircraft specifications are designed for high performance over a long service life. The design provides for uniform low pressure drop over a wide range of flow rates, and is chatter-free. The valves are available with anodized aluminum bodies and stainless steel poppets for pressures up to 1500 psi, or with cadmium-plated steel bodies and heat-treated steel poppets for 3000 psi service. Ports are male or female threaded in ⅛ in through 1 in OD. Flare angle meets JIC Standards. All types function in a temperature range of —65 F to 160 F and open under 4-8 pounds directional pressure. *16.*

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ROTARY WORK FEED TABLE

EVERY second the spindle stands idle to load or unload parts in the jig or fixture it costs you money.

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Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

25. "The Facts of Life" . . . The Logansport Machine Co., Inc., announces the first printing of a pocket-sized booklet, "The Facts of Life on Air and Hydraulic Devices". Each of the company's major lines—air and hydraulic valves, hydraulic and air-draulic cylinders, hydraulic power units and fluid lines and chucking equipment is treated in concise, matter-of-fact style by groups of "Do's", "Don'ts" and "What to Look For", covering phases of setting up and servicing each type of equipment. The company states that the material was compiled specifically for the use of tool engineers, designers and maintenance men. A lot of know-how has been boiled down into convenient, useful form. This booklet should save a lot of service calls.

26. Pneumatic Control Devices . . . The Industrial Division, Westinghouse Air Brake Co., has issued bulletin IDA 9481-1 listing the pneumatic controls and accessories for industrial applications which they offer. The 1, 2, 3 and 4-way Flexair valves, the single valve Controlairs, three-way, diaphragm and rotary on and off valves, actuators, reducing and check valves, filters are shown. Single and double acting cylinders in dia from 1 to 6 in with strokes from 2 to 10 in and two air cooled compressors—one single stage and one two stage—are also listed.

27. Hydraulic Oil Bulletin . . . A 16-page booklet, "Greater Efficiency for Industrial Hydraulic Systems", describing the Texaco Regal Oils (R&O) is available from The Texas Company. Specifications and service characteristics of the ten grades of oils in this line are given. A list of recommendations of leading pump manufacturers on grades of Regal Oils is included.

28. Pipe Line Filters . . . The line of Staynew pipe line filters for removing of foreign matter from air and liquids is described in an 8-page bulletin issued by Dollinger Corporation. The double action design which gives mechanical separation and filtering, models for absorption and filtering of oil, water and pipe scale are described in detail. Standard sizes range in capacity from 6 to 6000 cfm of free air and for operating pressures up to 3000 psig. All models are available in stainless steel, bronze or other non-corrosive materials.

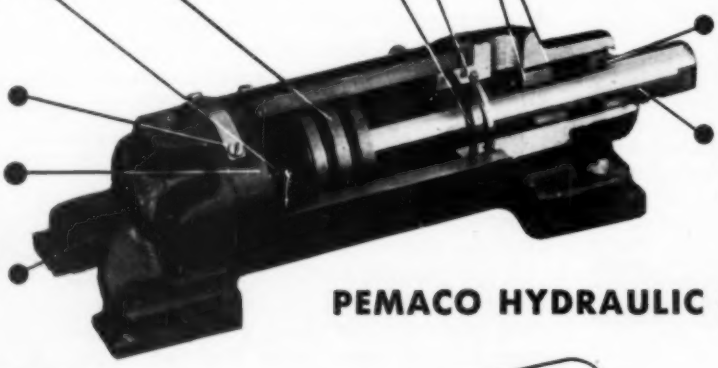
29. Hydraulic Hose Assemblies . . . Mulconroy Company, "hose specialists since 1887", review their three constructions of hydraulic hose in their leaflet, "Hydraulic Hose Assemblies". Wire braid construction for high pressure hose, rayon braid for medium pressure and either rayon or cotton braid for low pressure hydraulic hose; each length of all hose is equipped with two I.P.T. male couplings. Renewable couplings and adapter unions are also described.

CIRCLE NUMBERS ON THE CARD AND MAIL!

30. Standardized Compressors . . . Catalog No. 10, lists the tenth anniversary Series "K" models of the Air-Flo compressor for automotive and industrial purposes built by The Air-Flo Compressor Co. One standardized set of a limited number of parts are used to build a complete line of single and two-stage air compressors. Design and construction features, specifications of 36 models of series "K" bare pumps, servicing and performance fea-

PEMACO HYDRAULIC and AIR CYLINDERS

the last word in design and operation


AUTOMOTIVE TYPE PISTON RINGS
INTERNAL SNAP TYPE KEEPER RING
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"O" RING SEALS
"SEAL GUARD" RAM SCRAPER POSITIVE PACKING PROTECTION
BRONZE COVER PLATE
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Precision built with all parts tooled for interchangeability. Interior completely machined. Improved method of adjustable cushioning eliminates shock. No threads to strip. No parts to freeze.

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tures and data on industrial air cooled compressor outfits are given.

31. Accumulators . . . Bulletin 200, "Greer Hydro-Pneumatic Accumulators" is being distributed by Greer Hydraulics, Inc. The principle of operation is reviewed, the construction is detailed, a number of general uses are listed and specifications of six sizes from 10 cu in to 10 gal are given.

32. "Application Ideas" . . . Gast Manufacturing Corporation has issued Bulletin A-13, "Application Ideas". The new booklet describes 26 product design problems and their solutions. Examples show how air was put to work through Gast rotary air motors, compressors and vacuum pumps as original components of various machines and equipment. Three new V-belt air pumps just put into production are also described.

33. Hydraulic Pumps and Motors . . . An 8-page bulletin, "Berry Hydraulic Equipment", describes and gives full specification data on the two-stage hydraulic pumps and motors made by Berry Motors Incorporated. Two series of pumps and of motors are in the line; the smaller pumps, rated at 2 to 7 gpm, operate at pressures to 1000 psi; the larger pumps rated at 40 to 120 gpm have the same working pressures. Motors are rated at from 2.23 hp to 7.81 hp at 4000 rpm and 1000 psi in the smaller series and from 99.26 hp to 198.6 hp at 2000 rpm and 1000 psi in the larger. Pump or motor is fully reversible. Either foot or end-mounted models are available.

34. Hydraulic Control Hose . . . Catalog section 4030, just published by The B. F. Goodrich Company on their line of hydraulic control hose lists many of the recommended uses of this type hose, made with special wire braid to give greater toughness and flexibility. The hose is made for working pressures from 300 to 5000 psi, depending on size and construction. A method of calculating correct bending radii for various sizes and illustrations of reattachable couplings are features of interest.

35. Strainers and Filters . . . Basket Separator types of strainers and filters, class 72 series, are described and pictured in Bulletin No. A-1214, issued by The Kraissl Company. Removable baskets—strainers with mesh down to 1/64 in; filters with finer wire mesh cloth of crimp construction—are removable for cleaning. Units are available in single and duplex models, with tapped or flanged ports, of iron or bronze construction and in sizes to 4 in.

36. Air Traps . . . Bulletin No. 1433, published by Armstrong Machine Works, describes their three types of air traps made for air separators, aftercoolers, tanks and lines. Standard ball float, inverted bucket and the new "Snap-Action" air traps are shown with specifications, a table of air discharged through an orifice and a chart of water condensable from compressed air.

37. Instrument Selection Guide . . . Bulletin 98170, "Taylor Guide to Correct Instrument Selection", distributed by Taylor Instrument Companies, is a condensed catalog to the complete line of indicating, recording and controlling instruments made by them. Generously used photographs and drawings give many application suggestions. The index groups instruments for types of applications. References to detailed bulletins throughout make the guide very useful.

38. Unit Seal . . . The Gits Unit Seal is the subject of a four-page leaflet issued by Gits Bros. Mfg. Co. This seal, designed to improve seal performance on horizontal and vertical rotating shafts, is a self contained unit, the case contains both rotating and stationary sealing surfaces. The unit seal eliminates wear on shaft, bearing, race or other surfaces, is easy to install and is low in price.

39. "O" Ring Catalog . . . The Parker Appliance Company catalog No. 901 on their synthetic rubber AN and commercial "O" rings gives complete data on these products. "O" ring sealing and grooves, grooves for back-up rings, AN 6227 ring groove dimensions and specifications for two lines of com-

Every design engineer and production man interested in the many uses of hydraulic tubing will find Superior Bulletin #38 a useful, authoritative compilation of basic data.

Specific sections of the bulletin cover analyses, size ranges, lengths and tempers of Superior Hydraulic Tubing. Other sections give important facts on test procedures and the maximum working pressures of the tubing.

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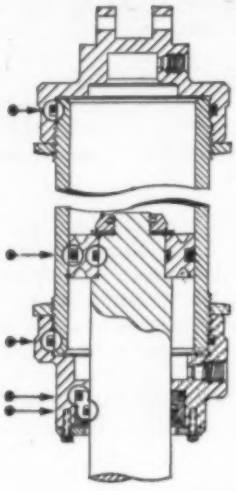

Guard These Critical Points

— by selecting GRC "O" rings to seal your air and fluid power transmission units.

• Carefully designed equipment deserves the certainty of these accurate, dependable sealing elements.

GRC "O" rings — are available in all AN6227 and AN6230 sizes to meet your design dimensions.

• Also non-standard sizes obtainable for special designed units.

GRC "O" rings — are supplied in varied proven compounds to satisfy normal or difficult conditions.

• An opportunity to develop special compounds to solve unusual applications will be welcomed.

GRC "O" rings — of silicone rubbers now offer you added opportunity for simplified equipment design where −80° to +500° F. temperatures are involved.

• Inquiries concerning this new and effective material as applicable in the "O" ring high-temperature and low-temperature uses will receive our immediate attention.

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Send for your free copy of "O" ring Catalog "C" illustrating this modern seal. Includes design, installation and recommended practice data.

Manufacturing quality mechanical rubber goods for 33 years

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mercial types (5427—both moving and non-moving sealing; 5430 for non-moving sealing) are included.

40. Gauge Catalog . . . Catalog No. 64, issued by United States Gauge, Division of American Machine and Metals, Inc., illustrates and describes the various types of gauges made by them. Pressure switches and gauges, two series of Supergauges, geared and gearless gauges, diaphragm and test gauges are all included as well as gauges for many special applications. The use, construction, sizes and ranges (with stock gauges indicated) and accuracy are given for all types of gauges.

41. Industrial Air Hose . . . New York Belting & Packing Co. is distributing their 8-page booklet, Form NY-9697-A on industrial air hose. Featured is their new molded neoprene tube air hose for severe use, available in sizes ½ to 1½ in. Standard and heavy duty air drill hose and several types of small hose for moderate air pressures are also shown.

42. Lubricators and Filters . . . A new Bulletin 1008-A-C, issued by M-B Products, describes the automatic air line lubricator and automatic air line filter and lubricator set up in combination. In the lubricator oil is metered positively and exactly from bowl into airline, controlled by a needle valve. An automatic venturi valve permits a limited amount of air to be passed with efficient oil pickup. The filter is designed for use with the lubricator. The units are available in five sizes ¼ to 1 in N.P.T.

CIRCLE NUMBERS ON THE CARD AND MAIL!

43. Re-Refining Used Oils . . . A bulletin "American Industry Speaks", issued by Filtrol Corporation, is the story of the applications of Retrol, an adsorbent in powder form for the re-refining, decolorizing and purifying of used oils. Retrol, according to the manufacturer, has the property of adsorbing carbonaceous sludge, acidic compounds and reducing odor.

44. Products Classification List . . . The Bristol Company, manufacturers of instruments for recording, indicating and controlling, have issued a Product Classification List of all their lines. The new list brings their Bulletin W1805 up to date.

45. Precision Valves . . . Hanna Engineering Works has just released Catalog No. 251 on Hanna Precision Valves. The complete line of valves for the control of air and hydraulic cylinders are illustrated, described; distinctive features and specifications are given in each case. Single and double pedal foot valves, three- and four-way hand operated valves, two-direction speed control valves, three-way pilot valves for direct control of small cylinder, the new four-way solenoid valve and the Mastair, balanced spool valve are included. A number of typical circuits are also shown.

46. Timing Motors . . . Catalog No. 47, giving full design, characteristics and specifications of the Synchron line of timing motors, timing machines and clock movements, is available from the manufacturer, Hansen Manufacturing Co., Inc. The Permag direct current timing motor, now available for general applications, was widely used as a servo component during the late war.

47. Air Valve Catalog . . . A new air valve catalog, issued as Section 301, has been published by Gerotor May Corporation. The file size, 20-page, two color booklet illustrates and describes the complete line of 21 models of Gerotor four-way air valves. Working drawings, specifications and cut-away views are shown for each model. Circuit layouts for important types of control show arrangement of all necessary air equipment with description of complete sequence of operation. The simplified Gerotor air valve design features corrosion resistant internal parts, bronze valve lines, large air passages. Suitable for pressures to 150 psi, the valves are shown in hand, foot, solenoid, cam and pilot types, in five sizes ¼ to 1 in.

LETTERS TO THE EDITOR

(Continued from page 25)

cover hydraulic developments and problems in this important field more completely and that Fred Hosterman will edit the section. Like many other manufacturers of hydraulic components, a number of our products are designed especially for the aircraft field, in which technical advances set the pace. We are sure that Hosterman will do a fine job for you.

F.M.

We have been aware from the publication of the first issue of APPLIED HYDRAULICS that some of the best design, application and maintenance work in the hydraulics field was being done in the aircraft field. Our new Aviation Hydraulics Section will, we are confident, round out our coverage of this important segment of the hydraulics field.

We couldn't resist the temptation to pass along this gem that Fred P. Peters of Materials & Methods reported in his March issue. In answer to the question, "Define a bolt and nut and explain the difference, if any", a girl in a high school science course examination wrote:

> **"A bolt is a thing like a stick of hard metal such as iron with a square knob on one end and a bunch of scratching wound around the other end. A nut is similar to a bolt only just the opposite, being a hole in a little chunk of iron sawed off short, with wrinkles around the inside of the hole."**

Try to do better, if you can!

Applied HYDRAULICS DIGEST

Abstracts, summaries and listings of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions pertinent to the hydraulics field.

Six Ways to Step Up Efficiency of Compressed Air Systems

Wm. H. Wheeler, *Factory Management and Maintenance,* v 107, May, 1949, pp 122-124.

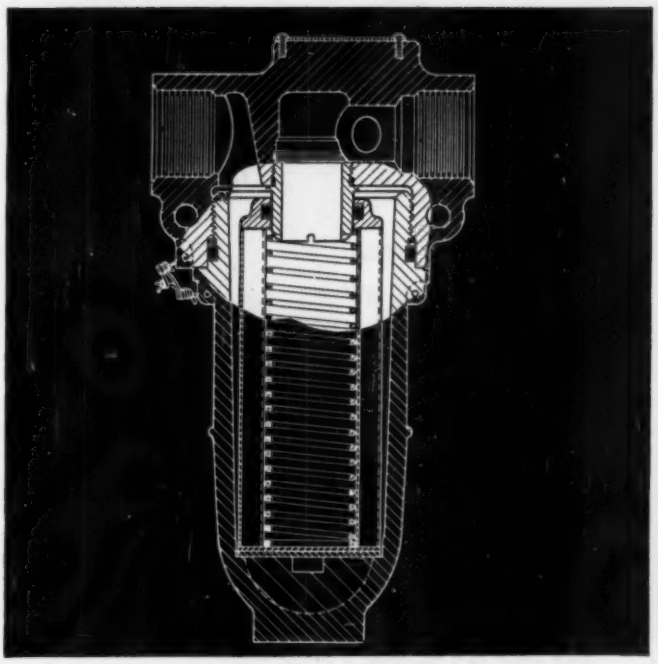
The chairman of the Educational Committee of the Compressed Air and Gas Institute, breaks down the cost of operating with air into four parts: (1) cost of compressed air; (2) cost of tool or machine with its repair and maintenance; (3) burden or load; and (4) labor. He logically outlines six steps to increase efficiency of compressed air systems: (1) select proper size and capacity of compressor; (2) introduce fresh air into the system; (3) use proper size of pipe or size, length and oil-resistant qualities of hose; (4) employ proper pressure at the tool or point of application; (5) select the proper tool for the job; and (6) establish and operate an adequate maintenance program.

Hydraulics and Pneumatics

O. A. Wheelon, *Product Engineering,* v 20, June 1949, pp 144-151.

The section on hydraulics and pneumatics is a part of a Special Report on the general subject of "Designing for Lower Costs". Other sections in this industry-wide survey include Materials and Constructions, Assembly Methods, Machine Elements, Electrical Equipment, Finishes and Standardization.

The hydraulic equipment is shown in designs of recent or current machines and in two cases the older design is shown or described to highlight the improvements of performance and economy in the new designs. The old and new design of the Elwell Parker lift truck shown together clearly shows the advantages of the new twin cylinder arrangement for lifting and tilting a 2000 pound upright pallet handling truck. The Logansport Machinery Company panel mounted R.F.L. unit is shown and the advantages of using such units to reduce assembly time are pointed out. The addition of a double-acting hydraulic coupling to the horizontal drive transmission of a motor driven hoist is pictured and described. The motor manufacturer, Robbins and Myers, Inc., reports improved performance, the ability to use a squirrel cage ac motor instead of the slip-ring motor previously used and simplified motor controls.



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Sealing Unlimited!

Yes, LINEAR "O" rings give unlimited sealing performance whether installed in aircraft units flying at high altitudes or operating in a thousand-and-one different installations on the ground. After exhaustive tests, Purolator Products determined that LINEAR "O" rings, used in their automotive and aircraft filters, are resilient and tough enough to fully withstand shock and vibration as well as extreme pressures and temperatures.

Purolator's new aircraft hydraulic filter illustrated here uses LINEAR "O" rings to resist pressures as high as 4800 p.s.i. and temperatures from as low as minus 68°F. to as high as plus 280°F. Purolator's experience is a good example of the versatility, reliability and simplicity effected with LINEAR "O" rings.

In addition to a long list of natural or synthetic rubber compounds adaptable to a wide range of temperatures, gases and liquids, LINEAR is successfully moulding "O," "V," "U" or other shapes of Kel-F, Teflon and Silicone for special applications. These special materials are suitable for seals from minus 320°F. to plus 400°F. against concentrated sulfuric, hydrofluoric, hydrochloric and other vigorous oxidizing materials.

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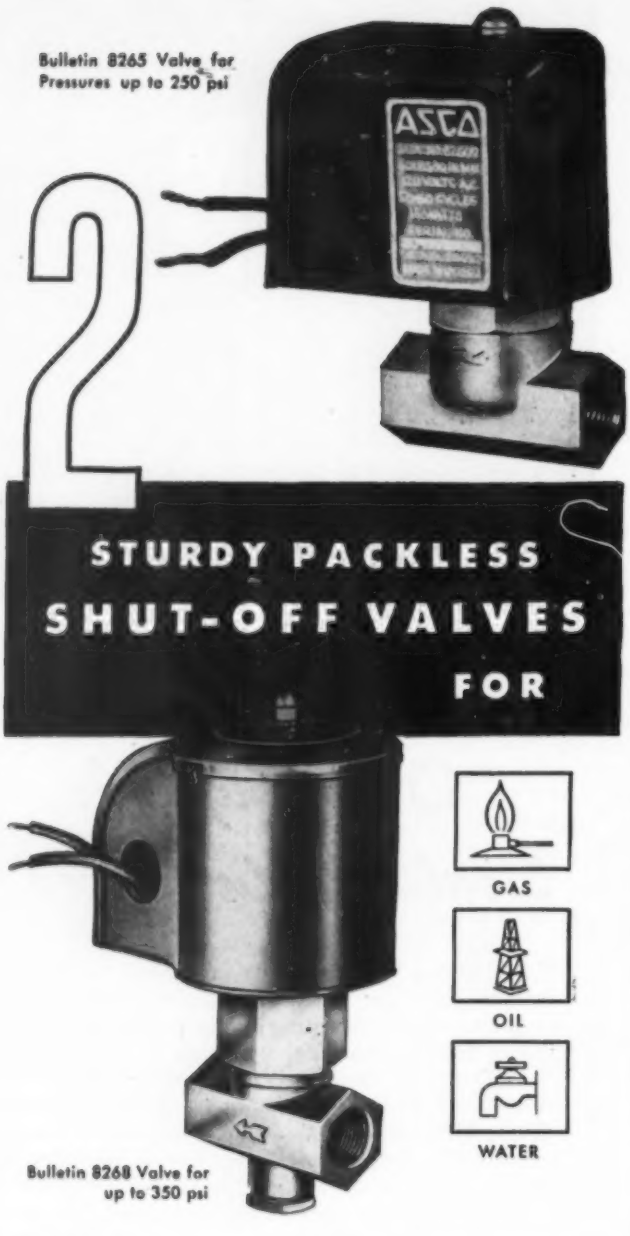

These ASCO Valves are small and compact with ample reserve power and large safety factors. Each is available with resilient seat and disc construction to assure absolute bubble-tight seating. The sturdy construction permits exceptionally fast and controlled operation.

Both valves have important "approvals". Bulletin 8265 valve is approved by Factory Mutual and Underwriters' Laboratories; Bulletin 8268 Valve is available with explosion-proof solenoid approved by Underwriters' for Class 1, Group D, Hazardous Locations.

Back of these and the many other ASCO Valves is more than 40 years' experience in the design, manufacture and application of solenoid valves. We know this field thoroughly and will be glad to serve you on any automatic control requirement. The above valves are for general purpose use in automatically shutting off the flow of gas, oil or water.

ASCO Solenoid VALVES

When in need of Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and Specialized Electromagnetic Controls, come to us.

Automatic Switch Co.

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DIGEST

The coupling provides a stepless range of speed acceleration and cushioning of the starting and, by jogging the start button, a fairly even speed can be maintained. Two accumulator designs are shown—one for supplying hydraulic pressure to loading cylinders on sugar rolls, reported by the Joseph N. Edwards Company, with advantages of simplified manifolding and piping, even wear and the substitution of small pump and motor units for large steam-driven pumps. The other accumulator design (Greer units on both jobs) incorporates two hydro-pneumatic units in the new flash welder made by the Federal Machine & Welder Co. Other units shown and described include a hydraulic vibrator for the Link-Belt Hydra-Flo Vibrating Feeder-Conveyor (original and a development design also shown), the advantages of gasket-mounted hydraulic valves and controls, using the Vickers pilot valve as an example; and the advantages of package power units.

Electrically Operated Valves

Frank E. Reeves, *Electrical Manufacturing,* v 43, June 1949, pp 88-95, 192, 194, 196, 198, 200.

A symposium treating the advantages, capabilities, limitations and features of construction of the available types of electrically operated valves. Cross sectional drawings, tables and flow diagrams cover the major industrial types. One table lists factors to be considered in selection of two-, three- and four-way valves; another larger table lists control, construction, body types, linings and materials and internal trim against sizes, pressures, materials to be controlled, operation, type of action, adaptability to metering, noise level, seating, leakage and operating speed. Packless, pilot-operated, diaphragm-operated valves, solenoid and motor operated valves of direct acting and secondary control types are analyzed and normal applications listed. Practically all industrial hydraulic designs are considered as well as some steam and water types.

Pneumatic Relays

James L. Dooley, *Machine Design,* v 21, April 1949, pp 109-115.

A brief, practical analysis of the two-way (shut-off) and three-way pneumatic relays, the pneumatic equivalent of the common electrical relay. Brake relay, pressure modulating type, relays for multiplication or division of pressure and various types of pressure transmitters are pictured and described. The errors in a modulating type relay are listed with suggestions for minimizing them.

Refuelling in Flight

C H. Latimer-Needham, from preprint of paper delivered at SAE National Meeting, Detroit, January 10-14, 1949.

This is a detailed study of the development and present status of equipment for the transfer of fuel from

DIGEST

the standard English tanker to several types of aircraft that have been equipped with the necessary receiver apparatus. The flight-refuelling equipment on the receiver consists of the bell-mouthed reception coupling, connected to a pipeline to the main fuel tanks. The coupling houses the ball end of the hose nozzle, neoprene seals and four hydraulically operated toggles form a fuel tight joint. The hauling line passes through the center of the reception coupling to the hydraulically operated windlass. The windlass is driven by a gear type hydraulic motor of approximately 3 hp output. Each main tank is supplied with an obturator valve which automatically shuts off the supply of fuel as filling takes place. Non-return valves in the main fuel valves prevent syphoning and reverse flow. Additional valves, which close automatically as the hose is disengaged, are fitted in the reception coupling. Fuel passes from the tanks of the tanker plane through a pipe containing the main hydraulically operated fuel cock to the axis of the hose drum. This drum is rotated by a hydraulic motor, which is also used to drive a winch mounted beside the drum for retrieving the contact line after contact has been made with the receiver's hauling line. The paper describes in considerable detail the economics of flight refueling, fuel and payload calculations and military applications to several types of aircraft.

A number of tables of operational data, charts on ranges, payloads, etc., and photographs, as well as a bibliography is included.

Machine Tool Lubrication

Anonymous, *Lubrication,* a monthly technical publication of the Texas Company, May, 1949.

The entire issue is given over to a discussion of machine tool lubrication on the production line. The selection and care of oils for hydraulic systems in machine tools is briefly but well covered, along with other lubrication problems. Photographs, diagrams and a table of recommendations for machine tool lubricants makes this a practical working tool for the maintenance department.

Hydraulic Mechanism for an Abrasive Cut-Off Machine

George D. DeGroat, *Machinery,* v 44, April 1949, pp 181-182.

The application of a hydraulic circuit with double acting cylinder, double-solenoid operated, four-way directional control valve, pump, valves and overload relay to automatically feed tungsten rod into a cut-off machine is described and pictured. The feed, previously manual, had resulted in a variable production rate and no accurate data on the rate of wheel wear per cut was available. The economical hydraulic setup provided for fully automatic operation and gave higher, constant production as well as closer control over wheel inventories through accurate wheel-life data.

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HYDRAULIC
Relief and Pilot Valves for Remote Control Circuits

Quiet Pilot Control up to 20 feet from Control Source

YOU GET RID of the noise problem for good in remote-control hydraulic circuits when you use Denison relief and pilot valves. They're chatter-free—really QUIET—even with the control as high as *twenty feet* from the relief valve. And their quietness is matched by their accuracy. You can set up convenient remote-control panels for any number of hydraulic circuits without the annoying squeals and howls you get from ordinary hydraulic valves.

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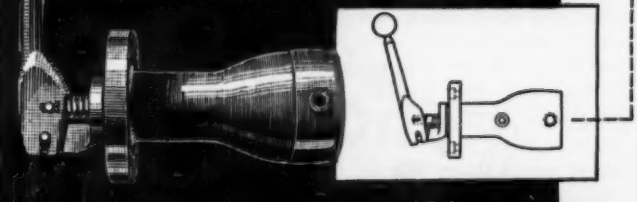

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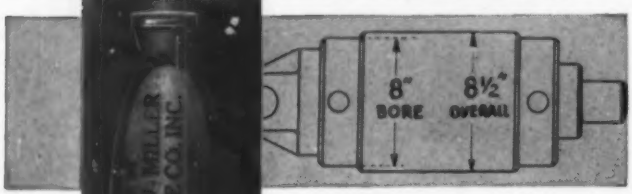

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No bolts or screws . . circumferential keys allow repacking in a matter of minutes. All machined steel with bronze bearing surfaces. Ports adjustable to any angle. Simplified cushion, no ball check required. Mountings interchangeable without dissassembling cylinder. 1,500 cycles per minute continuous duty guaranteed.
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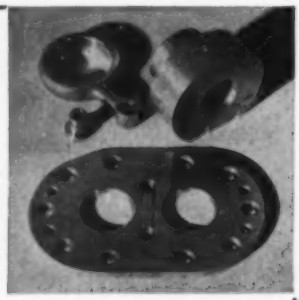

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THE AMERICAN CRUCIBLE PRODUCTS CO.
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DIGEST

How to Apply and Maintain Pilot Devices

J. M. Harney, *Factory Management and Maintenance,* v 107, April 1949, pp 83-86.

Three types of pilot devices: pushbutton stations; float and pressure switches; and plugging switches, covering in general manual, automatically operated and mechanically operated types of pilot devices. Each type is described, and suggestions for their selection, installation and maintenance are given. There is a useful table on trouble shooting.

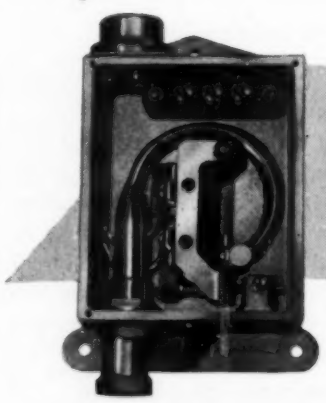
How the Salesman Can Create Inquiries

Bernard Lester, *Machinery,* v 55, June 1949, pp 211-212.

This is the unit of a series on "The Sales Engineer and His Problems".

It is pointed out that inquiries commonly develop in one of three ways: (1) the prospect, determines his own need and asks for a price and delivery date; (2) the prospect puts the problem of increasing his operating efficiency up to a potential supplier; and (3) the equipment salesman, through his own initiative, gains an opportunity to study his prospect's methods and techniques, uncovers a need, unrecognized before,

High Pressure Control



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★ Simplified Design
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DIGEST

thereby creating an inquiry. The author suggests that the skilled sales engineer proceeds as follows: (1) he selects his prospects carefully; (2) he sells an idea—not a machine or equipment—the idea that the salesman's engineering experience and skill in the direction of money saving may help the prospect; (3) the prospect's production problem is carefully analyzed, often requiring persuasion and diplomacy; and (4) with the need clearly developed, the sales engineer concentrates his sales effort to persuade the prospect to invest money in a specific improvement at a time when investment expenses are closely scrutinized. The advantages of this type of creative selling are pointed out as: (1) it establishes the sales engineer on a high level in his prospect's mind; (2) it places him in a superior position in regard to his competitors; often keeps competitors out of the picture; (3) it strengthens the individual selling morale of the sales engineer; and (4) it enhances the position and reputation of the machine or equipment supplier, as the customer gains a lasting impression that here is a company profoundly interested in helping him realize productive efficiency and greater profit.

Recent Air Force Research and Development Activities

General Joseph T. McNarney, AMC, *Technical Data Digest,* 1 June 1949, pp 13-19.

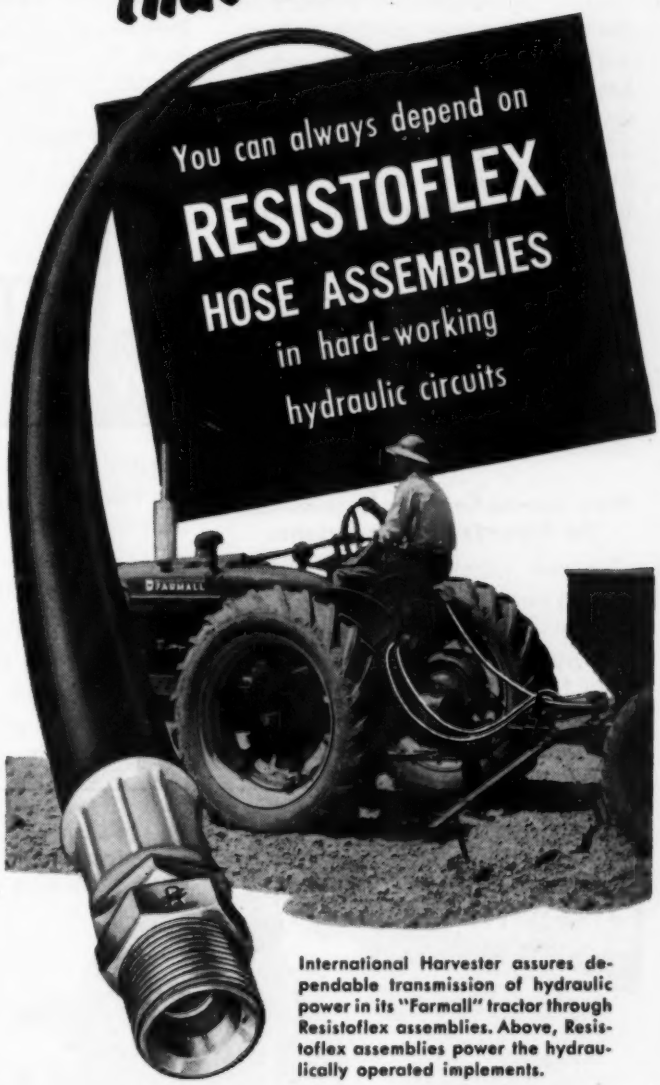
The three fields of research and development in the Air Force are described. The Complete Weapons Systems deals with aircraft, guided missiles and air defense systems. The second field, Major Components deals with items that make up a complete weapon, e.g., an airplane. The third field, Basic and Applied Research, treats materials, fuels, aerodynamics, research craft and the like. A few of the major new developments are touched upon: (1) guided missiles; (2) radar and control centrals; (3) power plants; (4) electronic devices; (5) high-speed cameras; and (6) ground handling and servicing equipment.

Servomechanisms Take Over

W. W. Bender, *The Martin Star,* May 1949, pp 7-9.

An orientation article on the place of the servo for automatic control, a part of the Special Weapons program at the Martin Company. The essential elements of a simple servo are shown in three diagrams: (1) the first lists the functional elements in a wheel chart; (2) the second gives the comparable physiological elements for a man stopping a moving car; (3) the third gives the units of an automatic pilot for correcting flight conditions. The article charts some of the projects engaged in by the 80 electro-mechanical engineers at Martin.

Need a Hose that can take it?



International Harvester assures dependable transmission of hydraulic power in its "Farmall" tractor through Resistoflex assemblies. Above, Resistoflex assemblies power the hydraulically operated implements.

You won't find many applications tougher on flexible hose than a farm implement. Yet, despite the constant movement, vibration and exposure, Resistoflex assemblies don't quit. These top grade lines keep hydraulic circuits functioning at full efficiency—keep a machine on the go. Any time you assure that kind of service, you can take customer satisfaction for granted.

Chances are that Resistoflex lines can do an outstanding job for you, too. Not only are they completely unaffected by flexing and vibration, but they're really impervious to hydraulic fluids and oils too. You run no risk of clogged mechanisms with this non-eroding hose.

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SYNTHETIC FLEXIBLE PRODUCTS AND PARTS FOR INDUSTRY

Hydraulic Nomenclature

The nomenclature on aircraft hydraulic and pneumatic systems was presented by L. S. Barksdale of Saval, Inc., as a proposed SAE Aeronautical Recommended Practice at the A-6 Committee meeting at Dayton last May. The project, which has been in process for about a year, was approved with the revisions and additions which had been suggested by Committee members and hydraulic engineers of industry and government. The basic definitions and terminology are expected to be valuable to designers, purchasing officials and manufacturers alike. It was recommended that the nomenclature be forwarded to the SAE Accessory and Equipment Subdivision for approval and coordination.

New Armed Services Regulations On Patents and Copyrights

A new joint regulation, Section IX, "Patents and Copyrights" has been adopted by the Army, Navy and Air Force and becomes effective July 1. Designed to be more liberal toward military contractors and at the same time fully protecting the government's interests, the new regulation is the eleventh section of the Armed Services Procurement Regulation issued under the program to develop unified procedures for use by all three departments. While the new section does not differ radically from the former separate requirements, in some respects it is less strict as to the amount of reporting to be done by contractors and, to some extent, liberalizes patent and copyright provisions to be included in military contracts. Copies of Section IX are available at the Government Printing Office, Superintendent of Documents, Washington 25, D. C.

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

John S. Barnes Corp., Rockford, Ill., has appointed Cincinnati Industrial Sales Co., Cincinnati, Ohio, as its sales representative in southern Ohio and southern Indiana.

Robert J. Minshall, president, Pesco Products Division, Borg-Warner Corporation, announces two additions to the executive staff of the company. John A. Lauck, chief engineer, has been appointed vice president. He has been with the company for 12 years. D. A. Sutherland, who has been serving as eastern sales manager for industrial products, was named industrial relations manager.

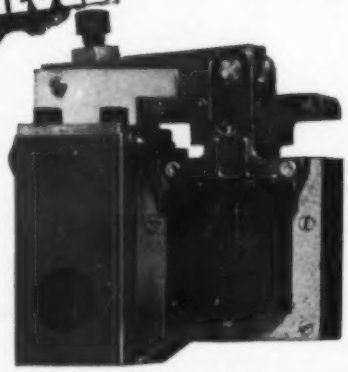
Herb Vickery, manager of the Rucker Company, Oakland, Calif., spoke before the national summer

NEW HIGH PRESSURE
SOLENOID VALVES

FOR 110-VOLT
60 CYCLE A.C.
CURRENT

Features

- Rugged compact construction
- 3000 P.S.I. operating pressure
- Continuous duty
- Poppet design eliminates leakage
- May be mounted in any position
- Impregnated coils resist moisture and condensation



Waterman High Pressure Solenoid Valves are inexpensive, compact units designed for continuous duty in hydraulic systems where pressures are as high as 3000 P.S.I. Poppet type construction gives positive sealing against internal leakage. Impregnated oil resistant coils make these valves suitable for mounting in oil reservoirs. In many cases this feature eliminates costly piping and makes possible the construction of smaller, more compact hydraulic power units. Available in ⅜" pipe size. Electrical requirements are 110 volt—60 cycle A.C. current.

West Coast: 918 No. Kenilworth Ave., Glendale 2, Calif.

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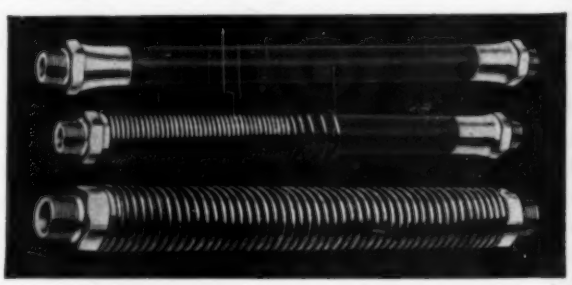

Complete Units . . . Easily Installed

Furnished promptly in any length—plain, or with short or continuous outer wire guards—in sizes from ¼" to 2". Made in three styles for requirements ranging from gravity flow to 10,000 lbs. p.s.i. in the ¼" size. Safe, durable, economical, for all types of hydraulically operated equipment. Couplings are brass or malleable iron, sealed-on or replaceable. *Write for new descriptive catalog.*

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meeting of the American Society of Mechanical Engineers, held at the University of California Extension Building, San Francisco, on June 30. Mr. Vickery's subject was "Factors Affecting the Selection and Application of High Pressure Pumps, Valves and Fluid Motors."

Ward Leonard Electric Co., Mount Vernon, N. Y., announces the opening of its new office building at 115 S. MacQuesten Parkway, Mount Vernon.

Fred T. Miller, general sales manager, and R. A. Stumm, Jr., assistant to the president of Adel Precision Products Corp., Burbank, Calif., have been named vice presidents of the firm by the Board of Directors, according to an announcement made by W. A. DeRidder, president. Mr. Miller will act as vice president in charge of engineering and sales; Mr. Stumm is vice president in charge of manufacturing, both of the Burbank Division.

Hall Kirkham, president, Hydraulic Equipment Company, Cleveland, announces the expansion of their sales organization on the West Coast. C. F. Rayment, sales manager of the company, has set up his headquarters in Oakland, Calif., for this purpose.

Ellinwood Industries, Los Angeles, has re-entered the aircraft hydraulics, electronics, component parts and accessories field.

Harold J. Zilske has been appointed sales engineer for The Parker Appliance Co., Cleveland, in the Philadelphia area. Zilske will specialize in tube fittings, valves, assemblies, "O" rings and other components for hydraulic and fluid handling systems.

The Hydraulic Press Mfg. Co. announces that Hydro-Power, Inc., their pump manufacturing affiliate, will hereafter be known as the Hydraulic Power Division of the company.

Eicher & Company, 263 Coleman Bldg., Seattle, Wash., have taken over the engineering, sales and servicing of Esterline-Angus recording instruments and associated products in the Seattle territory. Associated with H. L. Eicher, the senior member, are his son John Eicher and R. E. "Dick" Richards.

THE MARKET PLACE

CLASSIFIED ADVERTISING

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These columns are limited to Help Wanted or Position Wanted ads, and offerings of used equipment by the users of such equipment.

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Design engineer experienced in Hydraulics wanted by large manufacturer of tractor equipment and heavy excavating machinery. Must be capable of making own layouts and calculations. State fully experience and salary expected. Location Wisconsin. Write Box 4917, APPLIED HYDRAULICS.

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For 100 lb. or 50,000 lb., there's a T-J Air or Hydraulic Cylinder that's *right* for your requirements. Many standard sizes and styles... both cushioned and non-cushioned types. Precision-built... backed by 31 years of know-how... dependable. Write for catalogs. The Tomkins-Johnson Co., Jackson, Michigan.

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60 types to choose from

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3-WAY
4-WAY

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AFFILIATE: SINCLAIR-COLLINS VALVE CO.

Rely upon Valvair

Warren W. Matlock has been named industrial manager of the New York City branch of Brown Instruments division of Minneapolis-Honeywell Regulator Company, according to an announcement by William H. Steinkamp, field sales manager.

The De Laval Steam Turbine Co., Trenton, N. J., has named C. Richard Waller vice president and director of engineering and H. G. Bauer vice president and executive engineer.

Sperry Products Inc., Danbury, Conn., has appointed Judson G. Hyde as comptroller.

Ward Leonard Electric Co., Mount Vernon, N. Y., has established a branch office and warehouse at 420 South San Pedro St., Los Angeles. H. S. Eales is district manager and E. R. Slivinsky, assistant.

Dunbar Engineering Co., representatives of Edward Valves, Inc., East Chicago, Ind., has named W. B. Osgood as a partner in the firm. Edward Valves, Inc., is a subsidiary of Rockwell Mfg. Co.

The Twin Disc Clutch Company announces the appointment of Jack N. Yetter as sales engineer in charge of the Tulsa office and the promotion of Harry T. Peck from installation engineer to district sales engineer of the Dallas office.

Dr. H. B. Walker has been appointed manager of a newly established product development department by E. F. Houghton & Co., Philadelphia.

The Lyon-Raymond Corporation, Greene, N. Y., announces the election of George G. Raymond, Jr., as vice president. Raymond will continue to act as sales manager in addition to his new duties.

Parker Appliance Co., Cleveland, has named Hydraulic Power Equipment Co., Portland, Ore., as Oregon distributor for their line of tube fittings, valves and related equipment.

The fifth annual National Conference on Industrial Hydraulics will be held on October 26 and 27 at the Sheraton Hotel, Chicago. One important paper, by a recognized authority, will cover the comparison of hydraulic and electric servos.

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for SHOCK RESISTANCE

And who makes the direct action hydraulic gauges? Schrader, of course! In two styles of vertical scale—Standard Type—and now in the New SCHRADER HYDRODIAL . . . the dial gauge you can read 50 feet away. "Truly a heavy duty unit for hard rugged service." Pressure ranges: For Hydrodial Type—5-50 up to 500-5000 lbs. per sq. in. For Standard Type—5-50 up to 1500-5000 lbs. per sq. in. These gauges are not laboratory gauges, but truly work units that are at their best in surging lines. Write for information about Schrader Direct-Action Gauges.

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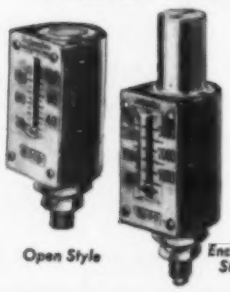

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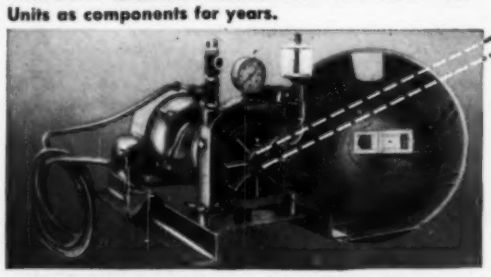
SOLUTION: Aeration of material with low pressure air (8½ c.f.m.; to 15 p.s.i.) from Gast Unit.

RESULT: Excellent. Manufacturer has used Gast Units as components for years.



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With simple, sliding-vane Rotary Design, Gast Compressors deliver *positive pulseless pressure . . . without bulky air tank . . .* at lower cost. Investigate Gast Units now.

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